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Cover The Missouri Botanical Garden's new Climatron, a geodesic dome greenhouse, is reflected in a lily pool at the century-old St. Louis Gardens. See page 1300.

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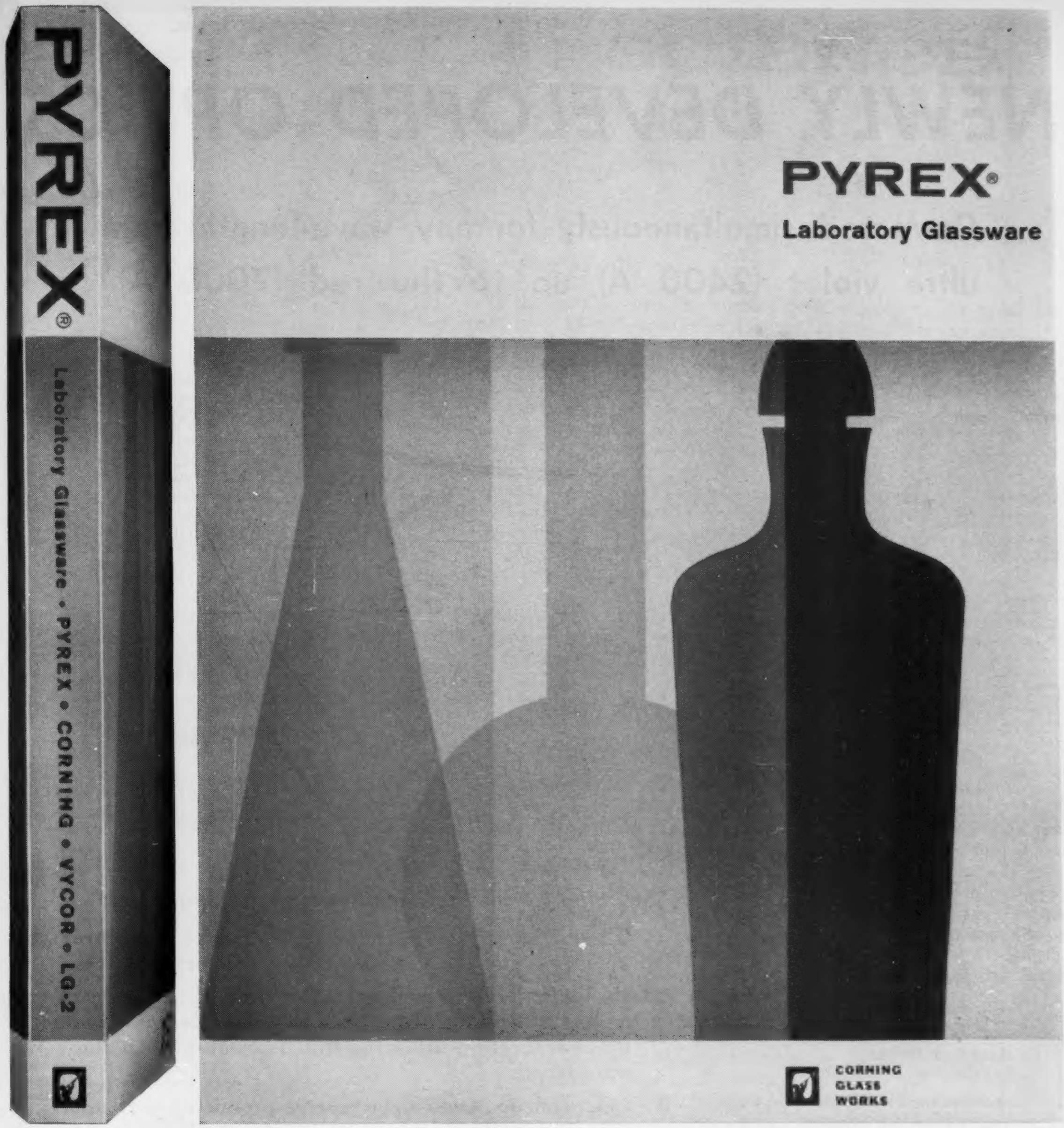
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Orbiting Words

In the last 20 years the number of telephones in the world has risen from 27 million to more than 192 million. This vast communications network is linked intercontinentally by radio, which varies in dependability with changes in the ionosphere, and by a few transoceanic cables. People here and abroad have been quick to see in communications satellites a way to escape from the present limitations on overseas communications.

Scientists of the American Telephone and Telegraph Company recently proposed to the Federal Communications Commission that the company be licensed to start an experimental program within a year. Ultimately, company officials would like to operate 50 active repeater satellites in random polar orbits to link 13 pairs of transmitter-receiver stations in different parts of the world. The cost of this system, which would provide 600 telephone circuits between each pair of terminals, would be about $115 million, if each satellite could be launched for $1 million and the ground installations cost $65 million. If a two-way television channel were to be added for each pair of terminals, costs would rise to $170 million.

It is apparent that A.T.&T. officials think the satellite proposal both technically and economically feasible. In this they are not alone. W. F. Hilton, writing in the British journal the *New Scientist* (6 October), states that relaying telephone calls by satellite will be "the most lucrative" of the civil uses of space and advocates a British program. He assumes that a satellite system could compete economically with cables and radio with only 50-percent launching success and a 1-year life for the satellites. If 90-percent launching success and a 22-year life could be attained, the cost of transoceanic calls could be reduced to one-fortieth of the present rate.

Both the British and the A.T.&T. proposals assume that the satellites would be launched "at cost." This means at immediate cost, but in this country Congress will have to decide whether account should be taken of the hundreds of millions of dollars that have made launching possible. Other policy questions arise. Should A.T.&T. be given a head start in commercial exploitation of space? What about the interests of other corporations? The same questions will have to be asked about other nations, for each has a valid claim to the use of space and to a fair allotment of frequency channels.

The limitations on available frequencies will, in fact, offer one of the greatest obstacles to establishment of a satellite network. The competition for channels is intense; the best channels for satellite use are already allocated for radar, public and private radio, radioastronomy, and experimental satellites. Should channels for commercial satellites be taken away from private users, whose allocations are under the control of the Federal Communications Commission, or from the military and civil defense, whose allocations are under the control of the Interdepartmental Radio Advisory Committee?

Even if satisfactory agreements can be worked out within the U.S., formidable obstacles remain. If the United States and the United Kingdom can agree on their shares of responsibility and on wavelength, they will still have to negotiate agreements with members of the International Telecommunication Union, which serves as the authority for frequency allocations among 101 nations. A formidable task for science and diplomacy!—G.DuS.

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CURRENT PROBLEMS IN RESEARCH

Semiconducting Compounds

New semiconductors reveal striking relations between composition and structure.

E. Mooser

In the last two decades electronic devices in the form of photocells, rectifiers, thermistors, transistors, solar cells, radiation detectors, and so on, have rapidly become of outstanding importance not only in research and industry but also in our everyday life. In spite of their widely varying applications and appearances, these devices have something in common: in one form or another they all contain some semiconducting material. As a result of this, a big effort has been made to come to a better understanding of the physics and chemistry of semiconductors. In particular, it was felt that the comparatively small number of semiconducting materials known at the beginning of the last decade was insufficient for our needs, and systematic searches for new semiconducting compounds have been undertaken.

The discovery and subsequent study of a new semiconductor is not only of help to the device engineer, who is constantly on the lookout for the material best suited for his purposes, but is also of fundamental interest because at present the only reliable way to come to an understanding of the influence of chemical composition and crystal structure upon the properties of semiconductors is to investigate series of chemically and structurally similar materials.

As a specific class of solids, semiconductors are perhaps best described in terms of their electrical conductivity, which is somewhere between that of a metal and that of an insulator. More accurately, semiconductors are nearly metallic at high temperatures and nearly insulating at low temperatures. The law — first established experimentally — which governs this strong dependence of the electrical conductivity σ on the temperature T is generally of the form

$$\sigma = A(T)\ e^{-\Delta E/2kT} \tag{1}$$

where $A(T)$ is a slowly varying function of temperature and ΔE is an energy. Moreover, the conductivity (at least at low temperatures) depends very much on the purity of the semiconducting material and, in the case of a compound, on any deviation from stoichiometric composition. Minute impurity contents (10^{14} to 10^{18} impurity atoms per cubic centimeter) and slight deviations from stoichiometry can increase the conductivity by orders of magnitude.

This behavior was first interpreted in 1931 by Wilson (*1*, *2*) in terms of the electron energy spectrum—the band structure—of semiconductors. When an atomic gas condenses to form a solid, the atomic energy levels widen into a series of energy bands. Wilson pointed out that in a semiconductor the number of electrons occupying these bands must be such that all bands up to and including the so-called valence band are completely filled at $T = 0$ and that the next higher band, the conduction band, must be empty and separated from the valence band by a finite energy gap ΔE which is of the order of the thermal energy kT (Fig. 1*a*). In contrast to this, the uppermost occupied energy band in a metal is only partly filled by electrons (Fig. 1*b*). Because at $T = 0$ all energy levels in the valence band are occupied, an electric field applied to a semiconductor cannot increase the translational energy of the electrons: there are no empty states of higher energy available for the electrons to move into. The electrons in the *completely filled* valence band therefore cannot carry an electrical current. However, if some of the electrons of the valence band are excited (thermally or otherwise) across the energy gap into the conduction band, they become free to move throughout the solid. Moreover, the "holes" left behind in the valence band by the excited electrons also contribute to the conduction, because, as can be shown, they behave like free, positive charge carriers.

Statistical mechanics tells us that at temperature T the number n of electrons excited across the gap ΔE, and hence the number p of holes in the valence band, is

$$n = p \propto e^{-\Delta E/2kT} \tag{2}$$

On the other hand, we know that the electrical conductivity resulting from the presence in a solid of n free electrons and p free holes is given by:

$$\sigma = ne\mu_n + pe\mu_p \tag{3}$$

where e is the electronic charge and μ_n and μ_p are the mobilities (that is, the velocities in unit electric field) of the electrons and holes, respectively. If we add that both μ_n and μ_p are slowly varying functions of temperature, then we see, by combining Eqs. 2 and 3, that theory does indeed reproduce the experimentally established Eq. 1.

To interpret the influence of impurities upon the conductivity of semiconductors, Wilson (*2*) further showed that impurity atoms introduced substitutionally into the lattice of a semiconductor are responsible for the occurrence in the band structure of additional energy levels. Thus, if the impurity

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atoms each have one valence electron less than the atoms which they replace, a normally empty energy level occurs at or slightly above the upper edge of the valence band. If the impurity atoms each have one valence electron more than the replaced atoms, a normally occupied level is introduced at or slightly below the lower edge of the conduction band. Electrons can then be excited thermally (or otherwise) from the valence band into the normally empty acceptor level (Fig. 2*a*) or from the normally occupied donor level into the conduction band (Fig. 2*b*). The net result of this is that in a semiconductor containing acceptor or donor impurities, or both, the numbers of both free electrons and free holes differ from the numbers found in the pure material. Equation 3 then informs us that this change in the numbers of charge carriers affects the conductivity, and this is indeed observed experimentally.

Chemical Composition of Semiconductors

While the amount of impurities in a semiconductor can be controlled within certain limits, other parameters, such as the energy gap, are essentially constants of the material, and their values cannot very well be altered. Moreover, the charge carrier mobilities, representative of yet another group of semiconductor parameters, while depending on

Table 1. The semiconducting $A^{III}X^{V}$ compounds.

AlP	GaP	InP
AlAs	GaAs	InAs
AlSb	GaSb	InSb

purity and crystalline perfection, cannot readily be changed in a *controllable* way. It therefore becomes essential to the device engineer to have at his disposal as many different materials as possible so that he can choose the one best suited to a certain application. But beyond the question of technical application, the scientist would like to establish the laws governing the dependence of the properties of semiconductors on their chemical composition, and, therefore, he too has an interest in new semiconducting materials. Moreover, the scientist would like to be able to predict the chemical compositions and crystal structures of any semiconducting phases that might occur in a system of two or more chemical components. The problems involved in making such predictions are beyond the reach of present-day theory, but the first step toward their solution was perhaps made when in 1952 Welker (*3*) predicted and found the semiconducting properties of compounds, such as indium antimonide (InSb), which are formed by the elements of group IIIB of the periodic table with the elements of group VB (see Fig. 3). We assign the general formula $A^{III}X^{V}$ to this family of compounds, thereby indicating that the electropositive partners $A, B, \ldots$ (the cations) are group III elements and the electronegative partners X (the anions), group V elements. Analogous formulas are used below to designate other families of compounds. A list of the semiconducting $A^{III}X^{V}$ compounds is given in Table 1, and in Fig. 3 the part of the periodic table which is of interest to us is reproduced.

Welker's predictions were based on his recognition of the chemical and structural similarities between the $A^{III}X^{V}$ compounds and the group IVB semiconductors silicon, germanium, and grey tin. In both the compounds and the elements the average number of valence electrons per atom is four. Moreover, the zinc blende structure of the $A^{III}X^{V}$ compounds is the same as the diamond structure of the group IVB semiconductors except that in the compounds the lattice sites are occupied by two kinds of atoms (*4*). Since the chemical bonds in compounds always have some ionic character, Welker concluded that they should be stronger than the purely covalent bonds found in silicon, germanium, and grey tin, and on the basis of this qualitative argument he predicted that the compounds aluminum phosphide (AlP), gallium arsenide (GaAs), and indium antimonide (InSb) should have larger energy gaps than the corresponding elements. Moreover, since stronger bonds lead to smaller amplitudes of the thermal vibrations, Welker further predicted that the charge-carrier mobilities in the compounds should also be larger. Both these predictions were subsequently confirmed by experiment.

Unfortunately, these "Welker rules," together with a series of other equally qualitative rules (for a compilation of such rules see, for example, *5*), are at present the only means at our disposal to predict the properties of new semiconductors, and it does not seem likely that this situation will change very much in the near future. If, however, we restrict ourselves to predicting semiconductivity rather than detailed properties, we are in a better position. Thus, Welker's criterion of chemical and structural similarity led to the discovery of the semiconducting properties of the $A^{I}B^{III}X_2^{VI}$ (*6*) and $A^{II}B^{IV}X_2^{V}$ (*7*) compounds such as copper indium telluride ($CuInTe_2$) and zinc germanium arsenide ($ZnGeAs_2$)—compounds which, like the $A^{III}X^{V}$ compounds, have an average of four valence electrons per

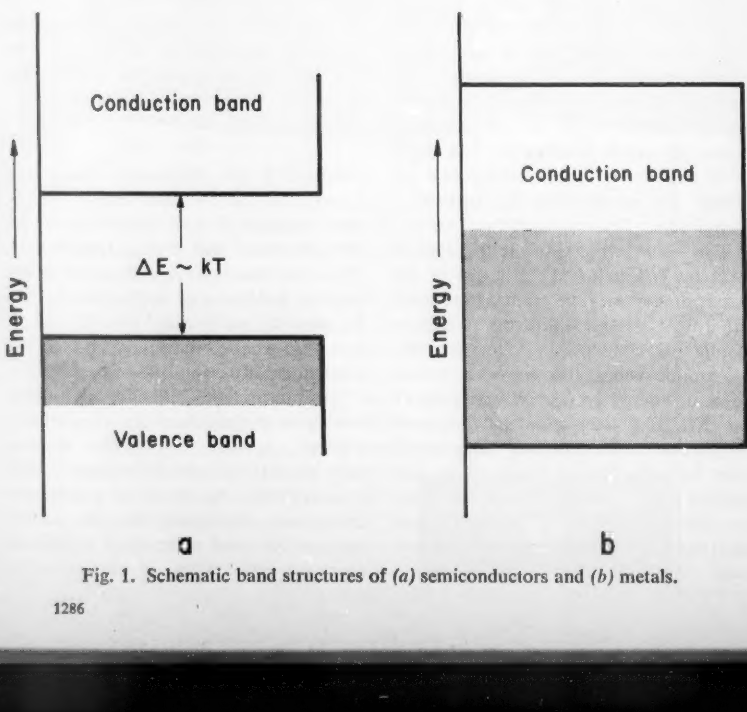


Fig. 1. Schematic band structures of *(a)* semiconductors and *(b)* metals.

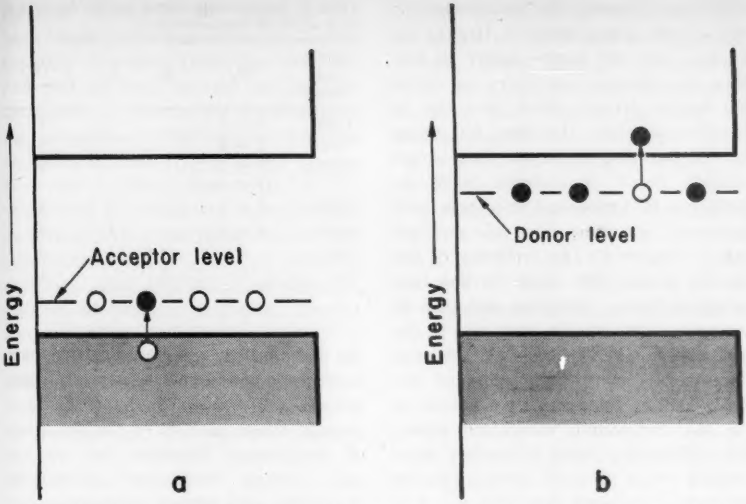


Fig. 2. Band structure of impure semiconductors with *(a)* an acceptor level and *(b)* a donor level.

atom and which have a chalcopyrite structure (see Fig. 6), in which the cations and anions also occupy the lattice sites of the diamond structure. However, there are many semiconductors for which this criterion does not apply, and in order to develop better means for predicting semiconductivity, a more generally applicable criterion was needed. Such a criterion evolved from a survey (*8*) made in 1956 of the chemical bonding in the then known semiconductors.

The bonds in semiconductors are predominantly covalent—that is, they resemble the bond formed in an H_2 molecule. When two hydrogen atoms approach each other their atomic orbitals—that is, the charge clouds associated with the movement of the electrons around the nuclei—begin to overlap until they can no longer be distinguished from one another. The two electrons are then equally shared between the two hydrogen nuclei, and their spins are paired (they point in opposite directions, see Fig. 4). Because covalent bonds result from an overlap of atomic orbitals of neighboring atoms and because most atomic orbitals are not spherically symmetrical, covalent bonds usually have strongly pronounced directional properties. We will see below that this is of considerable importance for the crystal structures of semiconductors. If a covalent bond occurs between two atoms of different kinds, then the electrons are no longer shared equally by them. Instead, the charge cloud formed by the bonding electrons is shifted toward the atom with the higher electronegativity, and the bond is said to have some ionic character. Finally, at large electronegativity differences the electrons are completely centered about the electronegative atom, and the bond is purely ionic.

An atom can form only a limited number of covalent bonds. As soon as the electrons shared by the atom with its neighbors, together with any unshared valence electrons, completely fill the valence subshells—that is, as soon as the valence of the atom is saturated—no further bonds can form. It can be shown that the completion of the valence subshells of the electronegative partners (anions) in a compound leads to a band structure of the type represented in Fig. 1*a*—that is, the compound is a semiconductor. If the electropositive partners (cations) of the compound have the necessary number of valence electrons to saturate the valence of the anions, then the total number N_e of valence electrons per anion must equal the number of states in the valence subshells of the anions. If, in particular, the anions require filled *s* and *p* orbitals—and this is the case in the vast majority of semiconductors—then

$$N_e = 8 \qquad (4)$$

The chemical composition of these semiconductors is, therefore, governed by the same valence rule which holds for many ionic compounds (see, for example, *9*), and one can summarize this discussion of the bonding in semiconductors as follows: Semiconducting compounds are normal valence compounds [exclusive of molecular compounds (*10*)] with predominantly covalent bonding. I should add that in a few semiconductors the total number of valence electrons exceeds eight. However, this electron excess can be compensated by the formation of cation-cation bonds such as are found, for example, in gallium telluride (GaTe) (*11*), where the gallium atoms form pairs. Similarly, a possible deficiency of valence electrons can be compensated by anion-anion bonds. As an example I might mention cadmium antimonide (CdSb) (*12*), in which the anions are linked in pairs. If b_c is the average number of cation-cation bonds formed by each cation and b_a is the average number of anion-anion bonds formed by each anion, then one can rewrite Eq. 4 in the form

$$N_e + b_a - b_c = 8 \qquad (5)$$

thereby taking into account the compensation of any electron excess or deficiency through the formation of bonds between like atoms.

		Group									
		IA	IIA	Transition Elements Groups IIIA — VIIIA	IB	IIB	IIIB	IVB	VB	VIB	VIIB
Period	2	Li				Be	B	C	N	O	F
	3	Na				Mg	Al	Si	P	S	Cl
	4	K	Ca		Cu	Zn	Ga	Ge	As	Se	Br
	5	Rb	Sr		Ag	Cd	In	Sn	Sb	Te	I
	6	Cs	Ba		Au	Hg	Tl	Pb	Bi	Po	At

Fig. 3. The periodic table (transition elements and rare earths excluded).

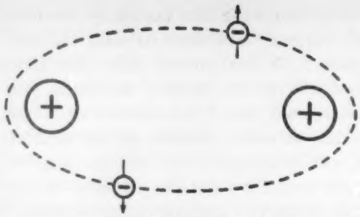


Fig. 4. The covalent bond in the H_2 molecule.

To illustrate this relationship, I have listed (Table 2) the appropriate values of N_e, b_a, and b_c for a series of semiconductors. It is noteworthy that Eq. 5 also holds for elemental semiconductors if in this case all the atoms are considered to be anions. This is a consequence of the filling, in elemental semiconductors, of the *s* and *p* orbitals of *all* atoms.

Through electron sharing an atom can, at the most, acquire as many additional electrons as the number of electrons it already has in its valence shell. In order that the octets on the anions can be completed by the formation of electron pair bonds, the anions, therefore, must have a minimum of four valence electrons. Indeed, all semiconductors for which Eq. 5 holds contain at least one element from groups IVB to VIIB of the periodic table.

Having discussed the rules governing the chemical composition of semiconducting compounds, let us look at a few of these compounds. The simplest among them are those of composition AX whose components lie symmetrically with respect to group IVB. They are the $A^{III}X^{V}$, $A^{II}X^{VI}$, and $A^{I}X^{VII}$ compounds, of which the $A^{I}X^{VII}$ ones, such as, for example, rock salt (NaCl), normally show ionic rather than electronic conduction. Owing to the large ionic component in the bonding (the difference between the electronegativities of the constituents is large), the energy gaps are large—larger in fact than the energies necessary to create the lattice defects which give rise to ionic conduction. However, by adding appropriate impurities to these compounds, donor or acceptor levels, or both, can be introduced into their band structure, and then electronic conduction is observed. The tendency of the heavier group IVB atoms tin and lead to retain their *s* electrons and thus to act as bivalent cations gives rise to the lead sulfide (PbS) family of semiconductors. By substituting pairs of *unequal* cations for every two cations of the AX compounds mentioned above, one arrives at a series of ternary compounds which all have semiconducting properties, provided only that Eq. 5 is not violated by the substitution. Best known among them are the $A^{II}B^{IV}X_2^{V}$ (*7*), $A^{I}B^{III}X_2^{VI}$ (*6*), and $A^{I}B^{V}X_2^{VI}$ (*13*) compounds like zinc germanium arsenide, copper indium telluride, and silver bismuth sulfide ($AgBiS_2$), which are direct derivatives of indium arsenide (InAs), cadmium telluride (CdTe), and lead sulfide, respectively.

Leaving the AX compounds and their ternary derivatives, I next mention the cation-rich compounds of composition A_2X. Perhaps the best known among them is magnesium stannide (Mg_2Sn) (*14*), in which the two magnesium atoms provide the four electrons necessary to complete the octet on tin. If in magnesium stannide we substitute a group VIB atom for tin and, to satisfy Eq. 5, a group IA atom for magnesium, we arrive at the $A_2^{I}X^{VI}$ compounds (Li_2Se and so on), whose crystal structure is the same as that of magnesium stannide. Little is known about their properties, but because of the large electronegativity differences between

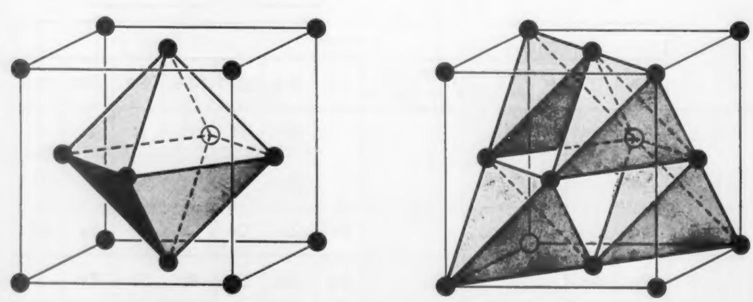
Table 2. Appropriate values of N_e, b_a, and b_c for a series of semiconductors.

Semi-conductor	N_e	b_a	b_c	$N_e + b_a - b_c$
InSb	3 + 5			8
PbS	2 + 6			8
In_2Te_3	[(2 × 3) + (3 × 6)]/3			8
CdSb	2 + 5	1		8
GaTe	3 + 6		1	8
Ge	4	4		8
Se	6	2		8

the components, one would expect them to be ionic conductors. There are some ternary derivatives of the A_2X compounds which also have the structure of magnesium stannide, but so far only lithium magnesium antimonide (LiMgSb) and lithium magnesium bismuthide (LiMgBi) have been shown to be semiconductors (*15*). A number of $A_3^{I}X^{V}$ compounds, such as lithium bismuthide (Li_3Bi) (*16*), and other alkali metal compounds are known to be semiconducting, and so is the ternary derivative lithium magnesium stannide (Li_2MgSn) (*17*), which has the same structure. To end the list of cation-rich semiconductors I mention the $A_3^{II}X_2^{V}$ compounds such as magnesium antimonide (Mg_3Sb_2), whose semiconducting properties have been studied in various laboratories (see, for example, *18*).

Considering anion-rich compounds next, we note that most of those of composition AX_2 are predominantly ionic. Nevertheless, there are some semiconductors of this composition, such as tin disulfide (SnS_2). Of the AX_3 compounds, the group VB triiodides (BiI_3 and so on) are known to be semiconducting. Most anion-rich semiconductors are, however, found at lower anion-to-cation ratios. Thus, semiconducting properties have been found in a series of $A_2^{III}X_3^{VI}$ (*19*) (In_2Te_3 and so on) and $A_2^{V}X_3^{VI}$ compounds. Among the latter, bismuth telluride (Bi_2Te_3) (*20*) has become rather important in the last few years because of its thermoelectric properties. Of the anion-rich ternaries, the $A^{II}B_2^{III}X_4^{VI}$ (*21*) compounds ($HgIn_2Te_4$ and so on) are known to be semiconductors.

The above list of semiconducting compounds is far from complete. Nevertheless it gives a good indication of the great variety of semiconducting materials known at present, and it also serves to illustrate the rules governing the chemical composition of semicon-



a b

Fig. 5. (*a*) The octahedral and (*b*) the tetrahedral holes in the close-packed cubic structure.

ductors. However, no mention has been made of compounds containing transition elements (titanium, iron, cobalt and so on), in spite of the fact that many of them show semiconducting properties. The reasons for this omission are that (i) we do not usually have an a priori knowledge of the valence of the transition elements and, therefore, the rules mentioned earlier cannot be applied to predict semiconductivity, and (ii) it is usually very difficult to produce transition element compounds in such a form that their *intrinsic* electrical properties can be studied accurately. Here, then, is a vast field of research open to both the theoretician and the experimentalist.

Crystal Structures of Semiconductors

Detailed data on the electrical properties are at present available only for the AX compounds. However, the crystal structures of all the semiconductors listed in the preceding section have been determined, and it is, therefore, possible to develop a systematics of semiconducting structures (*5, 17, 22*).

The bonds in semiconductors are predominantly covalent, and it was mentioned above that covalent bonds have pronounced directional properties. We therefore expect the arrangement of the neighbors of each atom in a semiconductor—in other words, the coordination of the atoms—to be typical of directed bonds. In fact, we expect tetrahedral and octahedral coordinations to prevail because they arise from the formation of tetrahedral sp^3 bonds and octahedral p bonds, respectively, and we know that it is mostly the s and p electrons which are involved in the bonding in semiconductors. Looking for three-dimensional arrays of equal atoms which are particularly adaptable for these coordination configurations, we find that close-packed structures contain one octahedral and two tetrahedral holes per close-packed site. Figure 5*a* shows the one octahedral hole lying completely inside the unit cell of the cubic close-packed (face-centered cubic) structure. Only the centers of the close-packed spheres are marked. In Figure 5*b* four of a total of eight tetrahedral holes lying within the unit cell are shown. It may be readily seen from these figures that if the anions of a compound form a close-packed array and if the cations occupy some or all of the tetrahedral or octahedral holes, or both, of the anion sublattice, then tetrahedral or octahedral coordination, or both, results. This filling by cations of the holes in a close-packed array of anions is the "Aufbau principle" of most semiconducting structures. Thus, Fig. 6 shows how filling by cations of half of the tetrahedral holes in a cubic close-packed array of anions leads to the zinc blende (ZnS) structure of many $A^{III}X^{V}$ (InSb), $A^{II}X^{IV}$ (ZnS) and $A^{I}X^{VII}$ (AgI) compounds and to the chalcopyrite structure of the ternaries of composition $A^{I}B^{III}X_2^{VI}$($CuInTe_2$) and $A^{II}B^{IV}X_2^{V}$ ($ZnGeAs_2$). Filling of all tetrahedral holes results in the fluorite structures of magnesium stannide and its derivative lithium magnesium antimonide. The rock-salt structure of many $A^{I}X^{VII}$, $A^{II}X^{VI}$, $A^{IV}X^{VI}$, and $A^{I}B^{V}X_2^{VI}$ compounds (NaCl, CdO, PbS, $AgBiS_2$) is obtained if the cations are filled into the octahedral holes. As indicated in Fig. 6, the structure of lithium bismuthide (Li_3Bi) (the same is true of Li_2MgSn) is a superposition of the fluorite and the rock-salt structures, both the octahedral and the tetrahedral holes being occupied. Partial filling of the cation sites of the zinc blende struc-

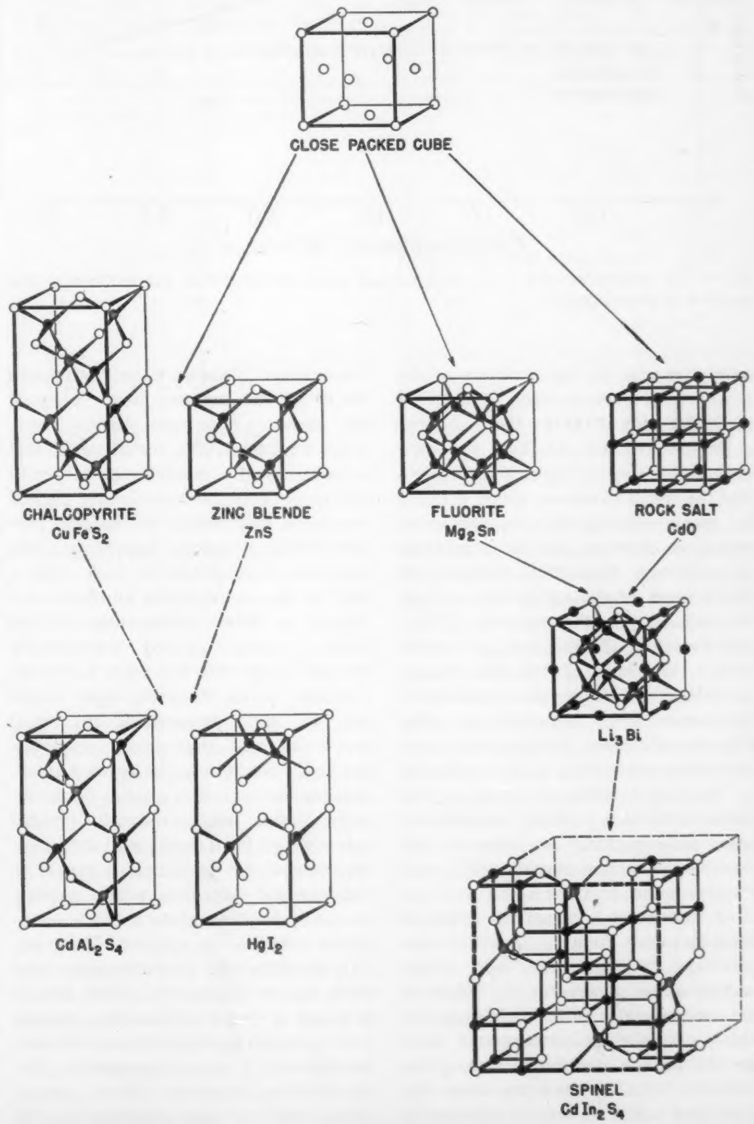


Fig. 6. Derivation of some semiconducting structures from the close-packed cubic structure.

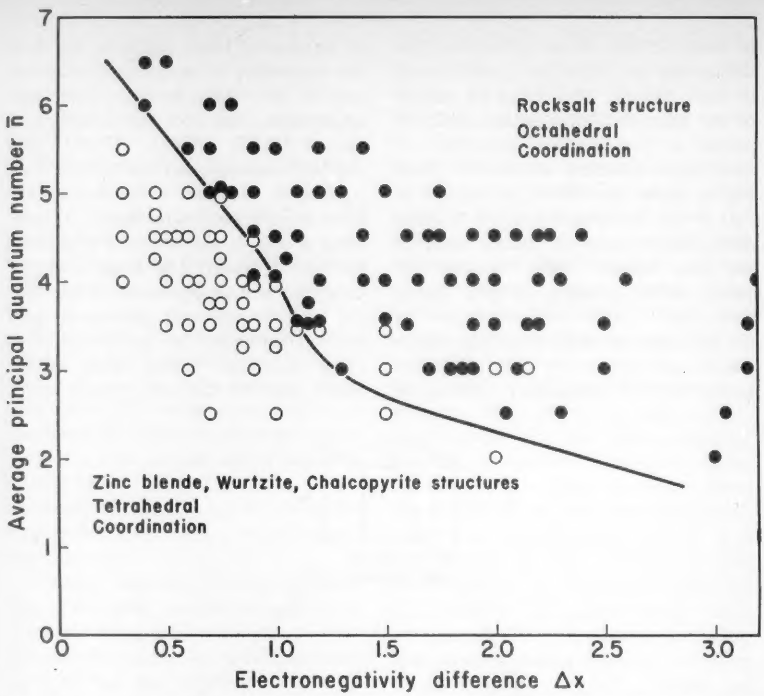


Fig. 7. *AX* structures with cubic close-packed anion substructures and tetrahedral and octahedral coordination.

ture gives rise to the structure of the ternaries of composition $A^{II}B_2^{III}X_4^{VI}$ ($CdAl_2S_4$) as well as to the structures of indium telluride (In_2Te_3) and mercury iodide (HgI_2). Figure 6 also shows that the spinel structure, which is found in many semi-conductors containing transition elements, can be considered as a lithium bismuthide structure in which some of the cation sites remain unoccupied. In the wurtzite (ZnS), nickel arsenide (NiAs), cadmium iodide (CdI_2), and bismuth triiodide phases, as well as in magnesium antimonide, the anions form a hexagonal rather than a cubic close packing, and again the cations are located in the tetrahedral or octahedral holes, or both, of the anion sublattice. More complicated anion close packings are observed, for example, in silicon carbide (SiC) and bismuth telluride (Bi_2Te_3).

At this point a series of questions come to mind: At what chemical compositions do structures with close-packed anion arrays form? When do the cations prefer to fill the tetrahedral holes, when the octahedral holes? How are the cations distributed among the available holes if there are fewer cations than holes? Is there a relationship between the chemical composition and the particular type of close packing of the anions? While we do not at present know all the answers, some progress has been made towards finding them. Thus we know (*23*), for instance, that nondirectionally bonded phases prefer highly symmetrical and densely packed structures which lead to the best possible filling of space. Accordingly, the numbers of neighbors of each atom—that is, the coordination numbers—are higher in these phases than in the rather loosely packed directionally bonded solids. We also know (*24*) that covalent bonds between light atoms have the most pronounced directional properties and that these properties gradually diminish as the bonded atoms become heavier. If in a series of chemically similar and covalently bonded solids we go from the light to the heavy representatives, we therefore expect to meet crystal structures whose packing gradually becomes denser and leads to higher coordination numbers. The group IVB elements and their structures may serve as an illustration. Solid carbon is found in two modifications, graphite and diamond, in which the coordination numbers are 3 and 4, respectively. The intermediate elements silicon, germanium, and tin also crystallize in the diamond structure, but in tin we already meet a second metallic modification (white tin) with a coordination number of 6. In lead this trend towards nondirectionally bonded metallic structures results in a cubic close packing with a coordination number of 12.

The same trend is observed in compounds, and it was found (*5, 22*) that the average principal quantum number $\bar{n}$ of the valence shells of the constituents is a convenient measure for the directional properties of the bonds in compounds (*25*). Strongly pronounced directional properties only occur at small values of $\bar{n}$. However, in compounds we must take into account also the ionicity of the bonds. Ionic bonds are nondirectional, and taking the electronegativity difference Δx as a measure for the bond ionicity, we expect densely packed structures and high coordination numbers whenever Δx is large. As an example, we consider compounds of composition *AX*. Plotting them in an $\bar{n}$ versus Δx diagram (Fig. 7), we find that the zinc blende and wurtzite phases, in which the cations occupy tetrahedral holes, fall within the lower left part of the diagram, where $\bar{n}$ or Δx, or both, are small. At large values of $\bar{n}$ or Δx, or both, on the other hand, we find the compounds crystallizing in the denser rock-salt structure (coordination number 6), in which the cations sit in the octahedral holes. Also plotted in Fig. 7 are the chalcopyrite phases of composition $A^{I}B^{III}X_2^{VI}$ and $A^{II}B^{IV}X_2^{V}$. They, too, are directionally bonded and therefore, like the zinc blende and wurtzite compounds, they lie on the lower left of Fig. 7. Here, then, we find a partial answer to the question of when the cations occupy the tetrahedral and when the octahedral holes. Moreover, since the majority of *AX* compounds crystallize in either the zinc blende, wurtzite, or rock-salt structure, Fig. 7 facilitates the prediction of the crystal structures of new phases.

The situation is somewhat more involved in compounds with anion-to-cation ratios differing from 1. Nevertheless, the directionally bonded phases still separate from the nondirectionally bonded ones on an $\bar{n}$ versus Δx plot, and valuable information on the systematics of semiconducting structures can be gained from such plots (see *22*).

Conclusions

Rather than describe the detailed properties of a few semiconducting compounds and the theoretical efforts that are being made to interpret them,

I have tried here to put the emphasis on those basic properties that are common to all semiconductors and that distinguish them from other solids. It is interesting as well as surprising to see how the many and various semiconducting compounds are all governed by the same simple chemical and structural rules. These rules present a challenge to the theoretician, who has yet to interpret them in a rigorous way. They present a challenge also to the experimentalist because they introduce him to large families of new and unexplored semiconducting materials. And the challenge is all the greater since it is to be expected that, as our knowledge of semiconductors and their properties increases, the chemical and structural rules will be reflected in at present largely unknown but much-sought-for relationships between the chemical composition and structure of semiconductors on the one hand and parameters such as energy gap and charge-carrier mobility on the other.

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Doomsday: Friday, 13 November, A.D. 2026

At this date human population will approach infinity if it grows as it has grown in the last two millenia.

Heinz von Foerster, Patricia M. Mora, Lawrence W. Amiot

Among the many different aspects which may be of interest in the study of biological populations (*1*) is the one in which attempts are made to estimate the past and the future of such a population in terms of the number of its elements, if the behavior of this population is observable over a reasonable period of time.

All such attempts make use of two fundamental facts concerning an individual element of a closed biological population—namely, (i) that each element comes into existence by a sexual or asexual process performed by another element of this population ("birth"), and (ii) that after a finite time each element will cease to be a distinguishable member of this population and has to be excluded from the population count ("death").

Under conditions which come close to being paradise—that is, no environmental hazards, unlimited food supply, and no detrimental interaction between elements—the fate of a biological population as a whole is completely determined at all times by reference to the two fundamental properties of an individual element: its fertility and its mortality. Assume, for simplicity, a fictitious population in which all elements behave identically (equivivant population, *2*) displaying a fertility of γ_0 offspring per element per unit time and having a mortality $\theta_0 = 1/t_m$, derived from the life span for an individual element of t_m units of time. Clearly, the rate of change of N, the number of elements in the population, is given by

$$\frac{dN}{dt} = \gamma_0 N - \theta_0 N = a_0 N \qquad (1)$$

where $a_0 = \gamma_0 - \theta_0$ may be called the productivity of the individual element. Depending upon whether $a_0 \gtreqless 0$, integration of Eq. 1 gives the well-known exponential growth or decay of such a population with a time constant of $1/a_0$.

In reality, alas, the situation is not that simple, inasmuch as the two parameters describing fertility and mortality may vary from element to element and, moreover, fertility may have different values, depending on the age of a particular element.

To derive these distribution functions from observations of the behavior of a population as a whole involves the use of statistical machinery of considerable sophistication (*3*, *4*).

However, so long as the elements live in our hypothetical paradise, it is in principle possible, by straightforward mathematical methods, to extract the desired distribution functions, and the fate of the population as a whole, with all its ups and downs, is again determined by properties exclusively attributable to individual elements. If one foregoes the opportunity to describe the behavior of a population in all its temporal details and is satisfied

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with a general account of its development over long stretches of time, the problem reduces to solving Eq. 1, except that N, γ_0, and θ_0 have to be replaced by appropriate mean values (γ, θ) taken over several generations, over all ages, and over all elements.

The difficulties encountered in establishing the distribution functions for γ and θ from observations of the behavior of the population as a whole should not be confounded with the predicament which arises if one drops the fictitious assumption that the elements are all thriving in a hypothetical paradise. While the former difficulties can be overcome by "merely" developing the appropriate mathematical apparatus to cope with this intricate problem, the difficulties in the latter case are of a different kind, since now the fate of the population is not any longer solely dependent upon the two intrinsic properties of the elements—their fertility and their mortality. Hazards in the environment, competition between elements for limited food supply, the abundance of predators or prey—to name just a few factors—may all act on either mortality or fertility or on both, and in the absence of further insight into these mechanisms, Eq. 1 becomes obsolete and nothing can be said about the long-term development of our population. The usual way out of this predicament is to devise plausible arguments which will link the two intrinsic properties of our elements with some of the characteristics of the environment, in the hope that the linkage is adequately described and also that one has picked those attributes of the environment which are most relevant in studying the population under consideration (*4*, *5*).

Environmental Influences

The usual approach in trying to account for the environmental influences is to make the productivity α in Eq. 1 a monotonic *de*creasing function of the number of elements N. Since, in an environment of given size, N is also a measure of the density of the population, it is easy to see that increased density may in many cases reduce the probability of survival for an individual element—for example, where increased density aggravates mutual competition or improves availability of elements for predators. A typical and popular choice of α is a simple linear dependence of the form

$$\alpha = \alpha_0 - \alpha_1 N \qquad (2)$$

which, inserted in Eq. 1, results after integration in what demographers prefer to call the "logistic growth curve," displaying a "sigmoid" shape, if N is plotted linearly against linear time (*6*; *7*, p. 67). The choice of this particular function is usually justified by our general observation that populations do not grow beyond all measures but settle down to a stationary value N_∞, which is given at once for $\alpha = 0$ from Eq. 2 as $N_\infty = \alpha_0/\alpha_1$. Furthermore, reasonable fits of the resulting function have been observed with actual biological populations—for example, fruit flies in milk bottles (*8*), bacterial colonies in petri dishes (7, p. 71), and so on.

Regardless of whether or not the simple expression given in Eq. 2 is still valid if the mechanisms of the interaction between environment and population are analyzed more carefully, there seems to be strong evidence that, for instance, in sexually reproducing species the advantages of having mates more readily available in larger populations is more than counterbalanced by the disadvantages resulting from a stepped-up competitive situation if more and more elements have to struggle for existence in a finite environment. In other words, the general idea that the productivity may decrease with an increase in the number of elements has undoubted merits.

Coalitions

However, what may be true for elements which, because of lack of adequate communication among each other, have to resort to a competitive, (almost) zero-sum multiperson game may be false for elements that possess a system of communication which enables them to form coalitions until all elements are so strongly linked that the population as a whole can be considered from a game-theoretical point of view as a single person playing a two-person game with nature as its opponent. In this situation it is not absurd to assume that an increase in elements may produce a more versatile and effective coalition and thus not only may render environmental hazards less effective but also may improve the living conditions beyond those found in a "natural setting."

The human population may serve as a typical example, as evidenced by its steady social build-up during historical time, its vigorous urbanization in recent centuries, and its extensive development of the means of mass communication in recent decades.

Since α, the productivity, reflects in a sense the living standard of the population, one is tempted to hypothesize that the productivity of populations comprised of elements capable of mutual communication is a monotonic *in*creasing function of the number of elements. Tentatively, let α be a weak function of N:

$$\alpha = \alpha_0 N^{1/k} \qquad (3)$$

where α_0 and $k \approx 1$ are later to be determined from experiment. Inserting Eq. 3 into Eq. 1, and integrating, yields, with the integration constant determined ($t = t_1 \ldots N = N_1$) at once the desired dependence of $N(t)$:

$$N = N_1 \left(\frac{t_0 - t_1}{t_0 - t}\right)^k \qquad (4)$$

where the characteristic date t_0 replaces a collection of constants:

$$t_0 = t_1 + \frac{k}{\alpha_0} N_1^{-1/k} \qquad (5)$$

For obvious reasons, t_0 shall be called "doomsday," since it is on that date, $t = t_0$, that N goes to infinity and that the clever population annihilates itself.

If "dooms-time" $\tau = t_0 - t$ (that is, the time left until doomsday), Eq. 4 can be rewritten as $N = K/\tau^k$. This form is listed below together with two other relations easily derived from Eqs. 3 and 4.

$$N = K/\tau^k \qquad (6)$$

$$\alpha = k/\tau \qquad (7)$$

$$\Delta t_p = (1 - p^{-1/k}) \cdot \tau \qquad (8)$$

where

$$K = \left(\frac{k}{\alpha_0}\right)^k \qquad (9)$$

In these equations the constant K represents the fundamental constants α_0 and k as seen in Eq. 9; in Eq. 7 the productivity is given as a function of doomstime and increases more and more rapidly as one approaches doomsday; Eq. 8 expresses the time interval Δt_p before a population which has N elements at time τ will have pN elements. If $p = 2$, one speaks about the "doubling time" of the population, and it may be

worth while to note that in this population, Δt_p, the "p-folding time" is a linear function of dooms-time, in strong contrast to exponentially growing populations, where these intervals are fixed for all times: $\Delta t_p = (1/\alpha_0) \ln p$, $1/\alpha_0$ being the time constant of the growth process.

Human Population

In order to check whether or not the hypothesis expressed in Eq. 3 has any merit at all, we took the human world population as a test case, since it was felt that the most reliable long-range data on the development of a population comprised of communicating elements may be found in the history of men. The use of estimates of the world population rather than of populations of certain geographical regions eliminates to a certain extent the influence of local fluctuations and migration. A bibliographical search produced 24 estimates (see *9–11*) of the world population, ranging over approximately 100 generations from the time of Christ ($t = 0$) almost to the present ($t = 1958$). These estimates were carefully checked with respect to their independence, and those which were suspected of being merely cross references in the literature were eliminated from the statistics in order to avoid improper weighting.

The method of least squares was employed in order to extract from the data the three values t_0, K, and k; the following values were obtained:

$$t_0 = \text{A.D. } 2026.87 \pm 5.50 \text{ years} \qquad (10a)$$

$$K = (1.79 \pm 0.14) \times 10^{11} \qquad (10b)$$

$$k = 0.990 \pm 0.009 \qquad (10c)$$

The root mean square deviation for all points considered is approximately 7 percent.

With these values Eqs. 6, 7, and 8 become, with $p = 2$:

$$N = 1.79 \times 10^{11}/\tau^{0.99} \qquad (11)$$

$$\alpha = 0.99/\tau \text{ per annum} \qquad (12)$$

$$\Delta t^2 = 0.445 \cdot \tau \text{ years} \qquad (13)$$

And finally, through Eq. 9, with Eqs. 10*b* and 10*c*, we obtain for α_0, $\alpha_0 = 5.5 \times 10^{-12}$

Figure 1 is a graphical representation of the accepted data together with the theoretical function (Eq. 6) for which values of Eq. 10 have been employed. By using logarithmic axes for the number N of elements, as well as for dooms-time τ, advantage has been taken of the fact that, if (and only if) an appropriate value for t_0 has been established, experimental results should appear on a straight line with negative slope k in a double logarithmic plot.

For convenience, the abscissa is marked on the lower margin in historical time t and reads from right to left, while on the upper margin, from left to right, dooms-time τ is indicated. Similarly, on the left margin of the abscissa the number N of elements is recorded, while the right-hand margin gives the global population density n in elements per square mile; this value is simply obtained by dividing the number of elements by the area A of all the lands of the earth: $A = 5.27 \times 10^7$ square miles. For comparison, some density estimates for 1958 are indicated.

From inspection of Fig. 1 and consideration of the small root mean square deviation of 7 percent, it may be seen that, even without making such generalizations as led to Eq. 6, Eq. 11 seems to serve as an adequate empirical formula for representing most of our recorded data on human population growth, covering a time interval of about two millenia. In the light of the interesting singularity supposed to occur at $t = t_0 \approx$ A.D. 2027, the question arises as to the reliability of an extrapolation beyond a time $t^* < t_0$.

It requires only simple calculations to show that if Charlemagne had had Eq. 6, with the evidence he could have had with respect to the world's population, he could have predicted doomsday accurately within 300 years. Elizabeth I of England could have predicted the critical date within 110 years, and Napoleon within 30 years. Today, however, we are in a much better position, since we are required to extrapolate our evidence only 4 percent beyond our last point of observation: we can predict doomsday within approximately 10 years.

Although it is always fascinating to imagine one's future fate, the possibility of deriving some fun by extrapolating our function into the past should not be overlooked. We find that 1 million years ago the world population was about 200,000 individuals, and 12 million years ago, not more than perhaps 15,000 of Hurzeler's Abominable Coal Men (*12*) populated Tuscany. If we wish to extrapolate much further into the past we must be prepared to find inconsistencies, since the assumption of the communicability of elements will to some extent lose its meaning. Thus, if one desires to calculate the date of the emergence of a hypothetical "Adam"—that is, $N = 1$—one finds it about 200 billion years ago. Even astronomers in their wildest speculations have not yet come up with an age of the universe which would approximate this figure [current estimates $\approx$ 24 billion years (*13*)].

Optimists versus Pessimists?

It is hoped that the preceding exposé will add some fuel to the heated controversy about whether or not the time has come when something has to be done about population growth control. This controversy has divided those elements of the population under consideration who profess to show some interest in human affairs into two strictly opposed camps (*14*): the optimists, who see in the population explosion a welcome expansion of their clientele, be it consumers of baby goods (*15*), voters, or devoted souls (*16*), and, on the other hand, the pessimists, who worry about the rapid depletion of the natural resources and the irreversible poisoning of our biosphere (*14*, *17*). While the optimists adhere to the thesis that no matter how fast the population is growing, food technology and the industrial sciences will easily keep pace with the development and thus will maintain the elements of the human population—at least for some generations to come—in a perfect state of economic and individual health, the pessimists prefer to paint the future of mankind in not quite the same rosy colors by pointing to the increasing growth rate of the population while assuming that industrial and scientific development will proceed at a much slower pace. Hence, the pessimists anticipate that further rapid increase in the population density will be accompanied by a deterioration in human dignity, and they see the ultimate fate of the human race as a mere vegetation of the individual on the edge of existence, *if* no measures are introduced to keep the world population under control (*18*).

When we refer to our population growth curve as given in Eq. 11 and in Fig. 1 and remember the premise under which it was derived, it is obvious that the optimist's viewpoint is

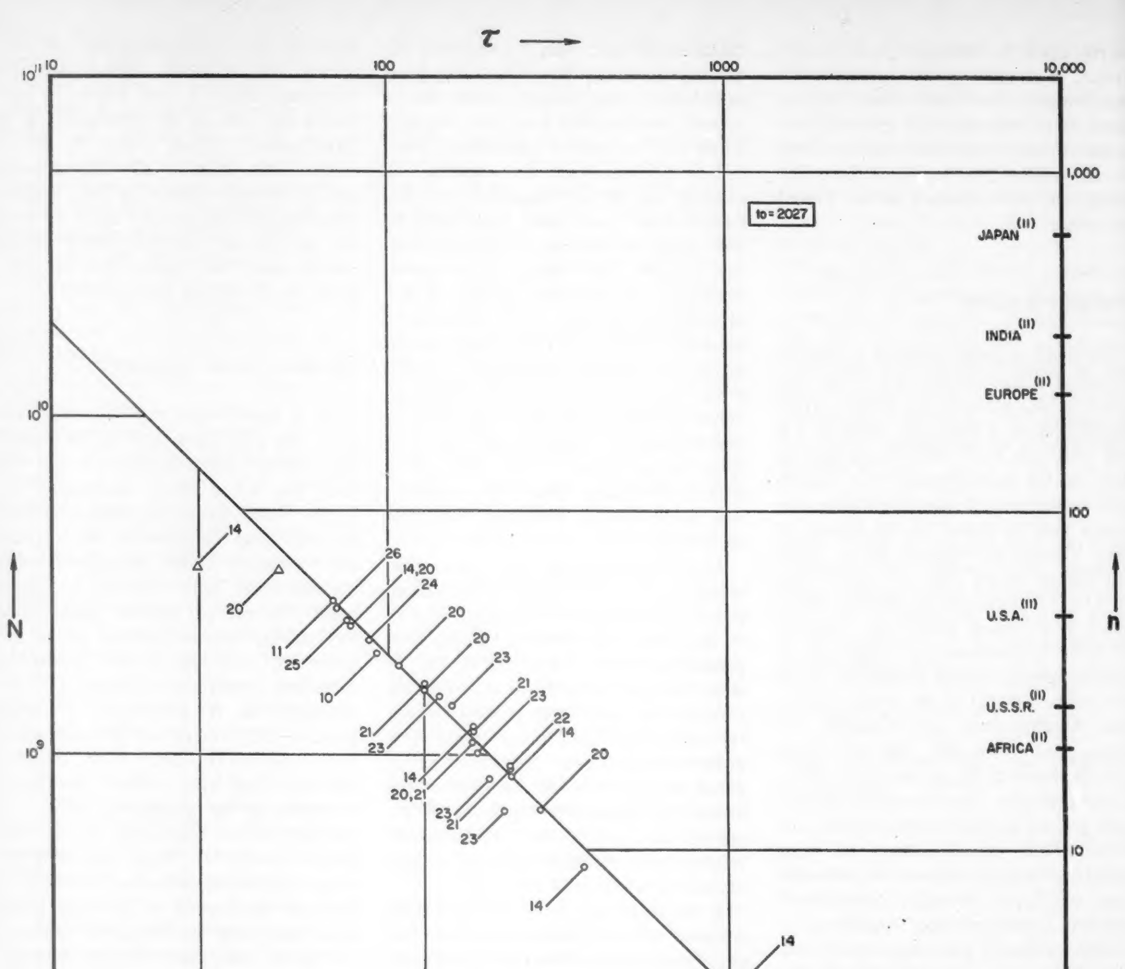

Fig 1. World population N (left scale) and world population density n in elements per square mile (right scale) observed (circles), calculated after Eq. 11 (solid line) and projected by different authors (triangles) as a function of historical time t (bottom scale), and of dooms-time τ (top scale). The numbers associated with each point are references.

correct: man has always been able to develop the appropriate technology to feed himself, or he has always produced the appropriate population to master his technological tasks. This can be conjectured from the relatively small deviations which actual population counts show as compared with calculated values, in spite of the fact that during the last two millennia men underwent several fundamental technological revolutions. Thus, we may conclude with considerable confidence that the principle of "adequate technology," which proved to be correct for over 100 generations, will hold for at least three more. Fortunately, there is no need to strain the theory by undue further extrapolation, because—and here the pessimists erred again—our great-great-grandchildren will not starve to death. They will be squeezed to death.

In view of this uncomfortable picture it is clear that, while the pessimists, one way or another, are "Malthusians by profession," the optimists must be "Malthusians at heart," hoping that at some time, somehow, something will happen that will stop this ever-faster race to self-destruction.

Population Servo

But in a highly communicating society there is no need to invoke good old Malthus again, who may cite this or that environmental factor whose abundance or depletion may curb excess productivity. There is no need to wait until an external mechanism influences human activity. Since today man's environment becomes less and less influenced by "natural forces" and is more and more defined by social forces determined by man, he himself can take control over his fate in this matter, as well as he has done in almost all areas of life where the activity of the individual has influenced his own kind.

There is no doubt that it will be extraordinarily difficult to establish a control mechanism, a "peoplo-stat" so to speak, which would keep the world's population at a desired level. The important point to note here, however, is that it is of secondary importance to find out what this level should be. The primary problem consists of finding means to keep it constant, whatever this level might be. This means that, if a particular N^*, supposed to remain constant, is chosen, obviously dN/dt must vanish, or $\alpha \rightarrow 0$; hence, $\gamma^* = 1/t_m^*$.

Since the tendencies today do not point in the direction of observable efforts to reduce the mean life span, t_m, of human individuals—on the contrary, we see a steady increase in this value—it is clear that our peoplo-stat has to control the fertility γ^*, and has to maintain it at the level $1/t_m$. Today, this means cutting the birth rate to about half its present value or, in other words, cutting the size of an average family to just a little above two children. Tomorrow, of course, it will be more difficult, since—as we have seen—the gap between birth rate and death rate is widening every minute.

Among the suggestions that have been advanced for meeting this problem—legislation, heavy taxation of families that have more than two children, cancellation of tax deductions, and so on—space travel has been proposed recently as an alternative (*19*). It is only unfortunate that no re-entry permit to earth can be given these space-trotters.

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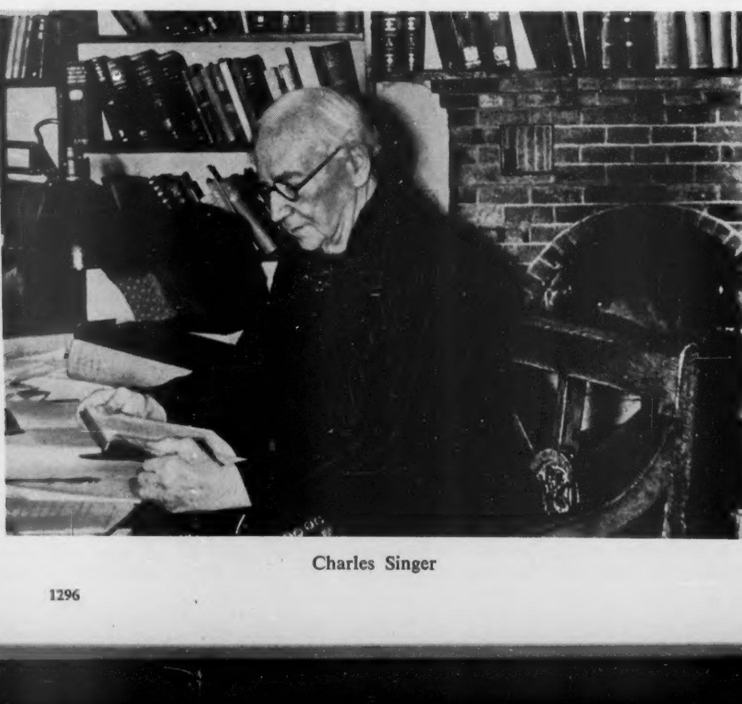
Charles Singer, Historian of Medicine, Science, Technology

In a long life in which he remained enviably active until the end, Charles Singer (1876–1960) found time for virtually three careers. As a young man he went up to Oxford as a scholar of Magdalen College and qualified in medicine in 1905; at once he embarked on extensive travels to enrich his medical experience. He went to Ethiopia, as medical officer to a surveying expedition, and to Singapore, Egypt, Greece, and Italy. After four years he settled in London to undertake pathological research and to build up a consulting practice, working at the Research Institute of the Cancer Hospital and at the Dreadnought Hospital for seamen. Not until just before the first World War did his attention turn seriously to the field in which he was later to establish an international reputation for scholarship, namely the history of science and medicine. An earlier interest in this was crystallized into a resolve to make it a full-time study by his marriage in 1910 to Dorothea Waley Cohen, herself an acknowledged scholar in this field. Thus began both a remarkable—indeed almost unique—husband-and-wife partnership and a second phase in Singer's career.

Circumstances made the early years of the partnership difficult. The couple went first to Heidelberg to extend their knowledge and experience and then, at Osler's invitation, settled in Oxford, where they became the center of a small but able group of scholars interested in the history of science. As an exceptional concession by Bodley's librarian, a room was set aside for them in the Radcliffe Camera. They had scarcely organized their lives for these new tasks, however, when the first World War broke out and Singer went back to orthodox medical practice, this time with the Royal Army Medical Corps. Posted to Salonika, he promptly availed himself of the opportunity to learn modern Greek. Equally characteristically, when his military service later took him to Malta he found time for archeological and anthropological research. Meanwhile, at home his wife was busy with her *Catalogue of Greek Alchemical Manuscripts in the British Isles*, which appeared in 1921. At the same time she was able to keep her husband supplied with books and papers so that despite the war and his service abroad he published the first volume of his *Studies in the History and Methods of Science* in 1917; the second volume appeared three years later.



Charles Singer

Singer returned to Oxford to a position more formal than he had had when he left, for he was appointed lecturer in the history of the biological sciences. His stay was short, however, for he soon moved on to University College, London, as lecturer in the history of medicine. There he remained until his retirement, his status being raised to that of professor in 1931. Retirement, however, marked not the closing of his career but the opening of a third phase in it. For reasons of health he elected to settle in the west of England. At his home at Par, in Cornwall, with its splendid view over St. Austell Bay, he established and extended his fine library and continued to work with undiminished vigor; to this period belong some of his major works. Such are, for example, *The Earliest Chemical Industry* (1948), *Vesalius on the Human Brain* (1952), *and A Short History of Scientific Ideas* (1959). The first of these, a history of the manufacture of alum, represented entry into a new field of learning—the history of technology—which firmly captured his imagination. Not long afterwards he initiated and was a joint editor of the *History of Technology*, of which the fifth and final volume appeared in 1958. Although the completion of this task was largely the work of younger colleagues, he maintained the closest interest in it to the end and, indeed, always looked upon it as one of the great achievements of his life. It was at Par that he died, still full of plans for new works, in his 84th year.

Such, in briefest outline, was Singer's career, but it does less than justice to his immense output of scholarly writing: even to list this here would require more space than is available. His nimble and inquiring mind ranged widely, and the subjects of his books include Anglo-Saxon magic (to which his *Early English Magic and Medicine* was a major contribution); the influence of Israel on the modern world; the evolution of anatomy (on which he gave a course of lectures at the Royal College of Physicians); and early herbals. Besides this, he contributed widely to the learned journals relating to his chosen sphere.

He was ever ready to support organizations devoted to the history of medicine and science. In the years of his retirement he was president of the British Society for the History of Science (1946–49) and of the International Society for the History of Science (1947–1950). The pursuit of his studies brought him many opportunities for travel. In the 1930's he lectured at Johns Hopkins—where he was later offered, but declined, the professorship of the history of medicine—and Philadelphia, and was for a year visiting professor at the University of California. A distinction that gave him particular pleasure was the honorary D.Sc. confered upon him by the University of Oxford in 1957. In 1953 his colleagues combined to honor him with a two-volume collection of historical essays—*Science, Medicine and History*.

Such were the outward manifestations of his erudition and experience, but what of the nature of the man himself? Of this it is difficult to write, for one of the penalties of living to an advanced age is that few, if any, contemporaries survive to recall one's early years. In character as well as in learning he was a man of parts, but the quality that many of his friends will best remember is his sense of humor, gentle and never malicious. Gentleness was, indeed, a quality that one quickly recognized, though one soon found it was a mistake to confuse this with lack of determination. He was, as he liked to proclaim, a man of peace, but if he set his heart on something he was always ready to try a different approach if the first one failed. More often than not his persuasiveness and tenacity carried the day. Again, behind a scholarly detachment from the mundane routine of daily life there lurked a mind astute enough where it had to deal with larger practical problems; one felt that while perhaps he could not boil an egg yet he was alive enough to the realities of any project of scholarship on which he had set his heart, whether on his own account or—more often—that of others. He was, indeed, always ready to help others, especially younger men, both in professional advancement or personal problems. This side of his character found many opportunities for expression during the German persecution of Jewish scholars in the 1930's. Himself the son of the rabbi of the West End Synagogue in London, his sympathy was at once aroused by the plight of refugees. Those of his coreligionists who escaped from the terror and made their way to England found him ever helpful to those shocked and bereaved by the foul excesses of the Nazi regime; to those whose interests lay within his own field he offered practical aid in rebuilding shattered careers. He played an important part in founding the Society for the Protection of Science and Learning.

Although his main interest was in the history of science, medicine, and technology his erudition extended far beyond this. He had a particular interest in the history of the Jewish race and religion and the relationship of the latter to Christianity. The *Legacy of Israel*, of which he was joint editor with E. R. Bevan in 1927, was an important, practical manifestation of this interest. He had a lifelong interest in biology and during the last war set up a teaching laboratory in his house at Par for the benefit of schools that had been evacuated to the West of England. In conversation there were few subjects to which he could not contribute something, always modestly, whatever the company. One had to be nimble-witted indeed to keep up with him even when he was in his eighties; as a young man he must have been formidable indeed. The world of learning is the poorer for his passing; one can only be thankful that he was spared for so long to make his outstanding contribution to it.

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Science in the News

Nixon and Kennedy on the Geneva Test Ban Talks, Disarmament; Conferees Await Election Outcome

The Geneva test ban negotiations became front-page political news last week. The negotiations did not immediately become a campaign issue, much to the relief of official Washington, but nevertheless the seeds of controversy were planted, and the situation may be quite different by the time this appears.

The Vice President announced that if elected he would move immediately to bring the two-year-old talks to a climax. In a speech he said had the approval of the White House, Nixon said that the day after the election he would ask President Eisenhower to send Henry Cabot Lodge to Geneva "with a view to resolving this question by February 1." "I would have Mr. Khrushchev understand that if, at the end of the 80-day period—by February 1—there is no progress, the United States will be prepared to detonate atomic devices necessary to advance our peaceful technology. . . . Further, I would have him understand that if an agreement is not signed within a reasonable period after February 1, the United States will have no alternative but to resume underground testing of atomic weapons."

Nixon said that if an agreement was in sight by 1 February (presumably if substantial agreement had been reached on the critical question of inspection rights) he would meet with Khrushchev and Macmillan "to make the final agreement at the summit." He said that he had no intention of breaking off the negotiations themselves, but that the unpoliced moratorium on testing that has been in force since the negotiations began in 1958 could not be continued much longer "without seriously jeopardizing the very objective towards which we hoped the Geneva negotiations would point—peace and human survival."

Nixon said that we have no assurance that the Russians have been obey-

ing the pledged moratorium on testing over the past two years and that, in the absence of some real indication that the Russians are prepared to accept an adequate system of controls and inspection, the United States cannot afford to continue the moratorium much longer. "During these two years of negotiation, we have not detonated any nuclear devices and the Soviets know that we have not. However, during the same period the Soviets have fired at least one large underground explosion and several small ones. They state that these have not been nuclear shots—simply high explosives. We have no way of knowing whether this is the fact. Nor will the Soviets permit us—or the United Nations, or neutral nations—to make an inspection. . . . The history of weapons development is such that it requires only between three and four years to complete a new breakthrough. Two years of this time has passed, as the United States has worked earnestly for this positive step toward eliminating the war threat to all humanity. Where has this left us? We have no agreement. There is reason to believe the Soviets may have used the time to attempt to overtake us. We cannot prolong the risk much longer."

Nixon said that if the Russians are serious about their professed desire to reach agreement on an adequate control system there is no reason that the agreement could not be substantially worked out in the 80 days between mid-November and 1 February. "We must resolve this issue now," he said. "We must never allow the Soviets, by deceit, to make America second in nuclear technology. We must act now to break this Soviet filibuster against peace and the security of the free nations."

Kennedy's Position

Nixon's proposal was similar to the position taken by Kennedy several weeks ago in reply to an open letter from Thomas E. Murray, a former member of the Atomic Energy Commission, asking both candidates to endorse an immediate resumption of underground weapon tests. "If elected," Kennedy said, "I will direct vigorous negotiations, in accordance with my personal instructions on policy, in the hope of concluding a realistic and effective agreement. . . . I intend to prescribe a reasonable but definite time limit within which to determine whether significant progress is being made. At the beginning of the period, I would direct the Atomic Energy Commission to proceed with preliminary preparations for underground tests.

"If, within the period," Kennedy said, "the Russians remain unwilling to accept a realistic and effective agreement, then the world will know who is to blame. The prompt resumption of underground tests to develop peaceful uses of atomic energy, research in the field of seismic technology, and improvement of nuclear weapons should then be considered, as may appear appropriate in the situation then existing."

Thus both candidates say that they would press the Russians to show that they are prepared to make the concessions on control and inspection necessary for an agreement; neither has committed himself to resumption of weapon testing at any specific date. (Nixon's proposal commits him to a resumption shortly after 1 February of the tests involving peaceful uses of nuclear explosions—Project Plowshare—but not to an immediate resumption of weapon tests.) Nevertheless, Nixon, in a part of his address which does not seem to have been widely reported in the press, was highly critical of Kennedy's proposal. His criticism raises the possibility that the negotiations could become a major issue in the last days of the campaign should Nixon choose to press his attack.

Nixon's Criticism

"My opponent," said Nixon, ". . . would want, even at this late date, to continue or reopen negotiations with the Soviets with new negotiators and new instructions. . . . He is saying, in effect, that the negotiations of the past two years have not been sufficiently vigorous and that [the negotiators'] instructions have not been adequate to the task. He is proposing a course of action which would delay any possible resolution of this vital matter for much too long—far beyond any margin of safety—since he is proposing to handle the matter with new men and new instructions.

"The delay, and Senator Kennedy's reasons for it, are both unacceptable. I say to him that it is impossible to imply in truth that these negotiations could have been pursued with greater vigor or sincerity on the part of Ambassador Wadsworth and our career negotiators and our top scientists. I say to him that no instructions would have produced agreement to date, except and unless we had been willing to sacrifice the principle of adequate inspection. The only major obstacle to an atomic test agreement has been, and is now, the Soviet refusal to accept adequate inspection. Clearly, then," Nixon said, "the only 'new policy instructions' through which the United States could remove this obstacle would entail surrender on this point. The security of the United States, and of the entire free world, simply will not permit either such a surrender or the indefinite continuation of the present moratorium entirely without inspection."

Nixon said he was referring to the position Kennedy had taken in his reply to Murray's open letter. "The people of the United States, like millions of people all over the world," Kennedy had said, "are anxiously hoping for an effective and realistic agreement outlawing nuclear tests—which means an agreement that is not dependent on faith alone, but one enforceable through an effective system of international inspection and control. . . . It is possible that our negotiators, who have earnestly tried to negotiate a realistic and effective test ban, have exhausted every avenue of agreement, but since I have neither taken part in the negotiations, nor had personal reports from the negotiators, who are not representatives chosen by me, I lack personal assurance of the futility of further discussion which alone would persuade me to urge the abandonment of so high an objective." It is not clear whom Nixon was quoting when he referred to the "new policy instructions" he said Kennedy planned. Kennedy did not use the phrase.

Difference in Attitude

Although Nixon's attack on Kennedy's position seemed a little contrived, there was a detectable difference of tone in the two men's statements on the question, and the difference is one that shows up whenever the candidates discuss the problems of the test ban and of disarmament generally. Nixon, in the few public statements he has made, normally begins by agreeing that the objective is important, but devotes himself mainly to warning of the danger of agreeing to anything without secure controls and inspection rights. This was the pattern in his statement on the test ban, and in his reply to the request of the *Bulletin*

of Atomic Scientists that both candidates give their views on the Geneva conference.

"There is no question as to our desire to enter into a disarmament agreement," Nixon said. "The problem is securing an agreement that is enforceable—because an agreement without adequate inspection provisions, which one party might honor and the other might not, would seriously and perhaps fatally increase rather than reduce the risk of war. . . . The road to war is paved with agreements based solely on mutual trust."

Kennedy, too, warns of the pitfalls of inadequately policed agreements. In his reply in the *Bulletin of the Atomic Scientists,* he went further and said that American forces, both conventional and nuclear, must be strengthened in order to increase world stability. But he differs from Nixon both in being less quick to place the entire blame for the lack of progress on the Russians and in talking much more of the necessity of pursuing disarmament. He has repeatedly criticized the Administration for not making what he regards as a sufficiently strenuous effort to see what can be done about disarmament. "Here is a gap as serious as the missile gap," said Kennedy, "the gap between America's incredible inventiveness for destruction and our inadequate inventiveness for peace. We prepare for the battlefield, but not for the bargaining table. We pour our talent and funds into a feverish race for arms supremacy, by-passing almost entirely the quest for arms control."

"I do not say," Kennedy went on, "that we should rely simply on trust in any agreement. Certainly we need an inspection system which is as reliable and thorough as modern science and technology can devise. However, even with such a system, there will be risks. Peace programs involve risks as do arms programs, but the risks of arms are even more dangerous. Those who talk about the risks and dangers of any arms control proposal ought to weigh—in the scales of national security—the risks and dangers inherent in our present course."

A Complex Problem

The whole problem of the test ban is one that is almost impossible for anyone outside the very highest circles of the Administration to assess. Nixon referred, in his statement, to the "obvious" need for a "foolproof" inspection system. If he meant this literally, then there will be no test ban agreement. The scientific testimony at the hearings of the Joint Congressional Committee on Atomic Energy last spring (*Science*, 29 April) made it clear that not even the most ardent supporters of a test ban claim that any inspection system possible in the immediate future could be described as foolproof.

The problem is not to decide whether the inspection system is going to be foolproof. Everyone knows it will not be. Any agreement will involve risks. The problem is to evaluate the risks. The temptations of a government to cheat on a test ban agreement depend on how important the expected gains from clandestine testing are compared to the risk of being caught at it, which would not only largely destroy the cheating nation's carefully built up "image" as a peace-loving nation, but eliminate for a long time the possibility of reaching agreement on other areas of disarmament. No nation, after all, could accept disarmament agreements based, as they must be, on less-than-foolproof controls, with a nation which had already demonstrated its readiness to cheat on such agreements.

To evaluate the risks one must have access to top secret assessments of the possibilities for advances in nuclear technology, to top secret military assessments of the significance of such advances, to other top secret assessments of the ability of our intelligence agencies to gather information that, combined with what can be learned through the formal inspection system, would offer a reasonably good chance to detect any violation of the agreement and a good probability that at least one of a series of such violations would be detected.

Other information needed relates to the state of Soviet nuclear technology and to expert evaluations of Soviet intentions as demonstrated by their negotiators at Geneva and the attitude of leading Soviet officials. An assessment must be made of the degree of risk the United States should accept in order to make some progress toward stopping the spread of atomic weapons and toward making some progress in slowing down the arms race.

The outcome of all this evaluation will be a decision based on a balancing of the risks one way or the other. It is a difficult decision for the President and the few others who have access to all the relevant information, which is far from as complete as they would like it to be. It is just not possible for anyone outside the very highest circles of the Administration to make a well-founded, firm decision on just what we should do about the Geneva talks.

The situation may well be that both sides are convinced that a test ban is in their mutual interest but that the talks will fail nevertheless because the Russians cannot bring themselves to accept the degree of inspection and control that would lower the American risk of accepting less than foolproof controls to an acceptable level.

Meanwhile, at Geneva, the negotiations entered their third year last week with everyone simply marking time until the election is decided. A. M. Rosenthal reported in the New York *Times*: "The United States delegation is not in a position to make any major moves until the elections are over. The British delegation is waiting for the United States. The Soviet Union's delegation has been relaxing for weeks, making it quite clear that it thinks nothing of any importance will happen until the United States elects a President."

The conferees have agreed on a good deal of the legal framework of a treaty that would provide inspection and controls to police a ban on underground nuclear explosions large enough to stand a reasonably good chance of being detected and identified by existing methods. The treaty would be accompanied by an unpoliced moratorium on smaller tests (those which would register below 4.75 on the seismic scale of earthquake magnitudes) and by an international research program to develop a system for policing the smaller tests.

But no agreement has been reached on either the length of the unpoliced moratorium on the smaller tests or on the more critical question of exactly what inspection rights the rival powers will hold. Nor has agreement been reached on a system of carrying out the trial underground explosions of nuclear devices which the West feels must be a necessary part of the research program to improve detection methods.

All that is being done at Geneva now is for both sides to exchange accusations over who is to blame for the long delay in working out answers to all these questions.—H.M.

News Notes

Burnet and Medawar Share Nobel Award in Physiology and Medicine

Sir Macfarlane Burnet, 61, professor of experimental medicine at Melbourne University in Australia, and Peter Brian Medawar, 45, professor of zoology at University College, London, have been named joint recipients of the 1960 Nobel Prize for Physiology and Medicine, which this year amounts to approximately $43,700. They are being honored for their "discovery of acquired immunological tolerance," by showing that under certain conditions a body can be induced to tolerate the transplantation of foreign tissue.


Peter Brian Medawar. [Basic Books]

All body cells in animal and man carry a distinct, individualistic immunological pattern. If a foreign immunity pattern is introduced through a tissue graft or organ transplant, an immunity reaction sets in and antibodies are produced that destroy the alien matter. A homograft usually takes at first, then dies in about 2 weeks and is sloughed off.

Theory Formulated in 1949

In 1949 Burnet, who heads the Walter and Eliza Hall Institute for Medical Research in Melbourne, formulated an immunity theory in which he held that a body does not inherit the capacity to "recognize" tissues of its own strain but that it gradually develops this ability during the embryonic period. He predicted that if foreign tissues were introduced during this formative stage, the body would later tolerate them if they were reintroduced.

This theory of acquired tolerance was proved valid by Medawar and his coworkers, who published a report in 1953. Mouse embryos were inoculated while in the womb with tissue from mice of a different breed. When similar tissue was grafted to the animals after birth, the operations were successful.

Medawar gives particular credit for this work to Rupert Billingham and Leslie Brent, who worked with him first as students and later as colleagues. Billingham now is at the Wistar Institute in Philadelphia.


Sir Macfarlane Burnet. [Australian Official Photograph]

Since the confirmation of Burnet's theory, it has been found that x-rays and cortisone can overcome the immunity barrier to foreign tissue in an adult animal that has not received prenatal treatment. This method was used recently at the Harvard Medical School in a successful kidney transplant from one brother to another.

The discovery of the tolerance phenomenon was described in the citation released by the Karolinska Institutet in Stockholm, which selects the annual medical award winners for the Nobel Foundation, as "a major breakthrough in the field of immunology" that has opened "a new chapter in experimental biology, with several problems of great practical medical importance laid open to attack."

Climatron Dedicated at Missouri Botanical Garden

The Missouri Botanical Garden in St. Louis dedicated its new climate-controlled display and research greenhouse, called "The Climatron," on 1 October. In addition to the trustees of the Garden, under the chairmanship of Robert B. Smith, many distinguished visitors were present. Detlev Bronk, president of the Rockefeller Institute, delivered the dedicatory address. Mayor Tucker, Chancellor Shepley of Washington University, Father Hastings of St. Louis University, and William C. Steere, director of the New York Botanical Garden, gave short talks.

The Climatron is unique in that it has two separate air-conditioning systems, one of which operates during the day and the other during the night. Each system is designed to produce a gradient of temperatures throughout the building, and the two systems operate in different directions at an angle to each other of 90°. This makes it possible to maintain an entire range of climates in different parts of the house, but with no physical separation of the various areas. Another special feature is the indirect lighting; 112 large lamps project their light against the Plexiglas cover of the greenhouse, and the light is then reflected back into the growing areas.

Construction of the new greenhouse is the first phase of a master plan for redevelopment of the Garden that has been worked out by Frits W. Went,

who became director of the Garden in 1958. An outgrowth of Went's studies in climate-control systems, made while he was professor at the California Institute of Technology, the Climatron is the first completely air-conditioned and moisture-controlled display greenhouse ever built.

Following structural principles established by Buckminster Fuller, inventor of the geodesic system, the architects designed a dome-shaped structure 175 feet in diameter that rises more than 70 feet at the center without a single interior support. Lined by a layer of Plexiglas suspended from the aluminum framework, the dome is supported at five points on a circular concrete base, which contains all the mechanical equipment.

The dome provides a shadowless enclosure, giving a feeling of natural space that simulates the open sky. The Climatron has a two-level interior, the

Satellites in Orbit

This table gives data on the 17 man-made objects in orbit on 1 November. The weights, especially for some of the larger satellites, include the last stage of the orbiting rocket. Figures for the actual payload weight were not available. In general, the United States appears to be well ahead of the Russians in bringing back scientific data from space. The Russians remain well ahead in rocket thrust, and possibly in their ability to recover objects from orbit. The data were furnished by the National Aeronautics and Space Administration.

Name	Type	Date	Weight		Lifetime		Initial distances	Scientific value	Transmitting data
			Total	Payload	Total	Useful			
Explorer I	Cylinder	31 Jan 58	31 lb	18 lb	3–5 yr	105 days	217–1573 mi	Geiger counters and micrometeorite detector. Discovery of Van Allen radiation	No
Vanguard I	Sphere	17 Mar 58	3¼ lb		200–1000 yr	Indefinite	409–2453 mi	Thermometers. Geodetic studies	Yes
Lunik I	Sphere	2 Jan 59	3245 lb	800 lb	Indefinite	65 hr	Solar orbit	Follow-up of Sputnik III findings on the ionosphere, atmospheric density, and cosmic rays	No
Vanguard II	Sphere	17 Feb 59	21½ lb		Indefinite	27 days	347–2046 mi	Placed in orbit	No
Pioneer IV	Cone	3 Mar 59	13½ lb		Indefinite	90 hr	Solar orbit	Geiger counters, de-spin device. Data on Van Allen radiation penetration and extension into space	No
Explorer VI	Spheroid with vanes	7 Aug 59	142 lb		2 yr (?)		156–26,357 mi	Magnetic field measurements; cloud-cover scanning; whistler radio experiment; detailed cross section of radiation surrounding earth	No
Vanguard III	Sphere and cylinder	18 Sept 59	100 lb	50 lb	30–40 yr	85 days	320–2320 mi	Magnetic measurements; temperature and micrometeorite measurements	No
Explorer VII	Cones	13 Oct 59	91½ lb		20–30 yr	1 yr	344–673 mi	Measurements of Van Allen and cosmic radiation; study of earth's heat balance, micrometeorites	Yes
Pioneer V	Sphere plus vanes	11 Mar 60	95 lb	40 lb	100,000 yr	106 days	Solar orbit	Long-range communication; studies of solar-flare effects, particle energies and distribution, magnetic field in space	No
Tiros I	Cylinder	1 Apr 60	270 lb		50–100 yr	78 days	429–466 mi	Cloud-cover photography	Yes
Transit IB	Sphere	13 Apr 60	265 lb		16 mo	1–3 mo	233–479 mi	Navigation system for ships and aircraft	No
Spacecraft		15 May 60	5 tons		Indefinite		188–229 mi		No
Midas II	Cylinder	24 May 60	2½ tons		40 mo	2 days	292–322 mi	System for detecting missile launchings with infrared sensors	Yes
Transit IIA	Sphere	22 June 60	223 lb		50 yr	1 yr (?)	389–665 mi	Detection of "galactic noise" radio waves	Yes
NRL satellite	Sphere	22 June 60	42 lb		50 yr	1 yr (?)	382–657 mi	Measurement of solar radiation	Yes
Echo I	Sphere	12 Aug 60	240 lb		Indefinite	Indefinite	945–1049 mi	Communications satellite with reflective aluminum surface	Yes
Courier IB	Sphere	4 Oct 60	500 lb	300 lb	Indefinite	1 yr (?)	501–658 mi	Communications satellite	Yes

lower stage containing a lily pool, planted with specimens from the Garden's world-famous collection of water lilies; this is connected to a series of rice paddies displaying rice in various stages of development. In this area there are also a Hawaiian garden profusely planted with tropical flowers and a tropical mist forest.

On the upper level there is a greater variety of plants—ranging from coffee, tea, and rubber plants in one section to vegetation of a steaming Amazon jungle in another.

New Program in Space Geology Announced by Geological Survey

The U.S. Department of the Interior has announced that the Geological Survey is launching a research program in astrogeology that will be financed by the National Aeronautics and Space Administration. The program includes geologic analysis of photographs of selected areas on the moon; studies of terrestrial craters; investigations into the origins and composition of tektites, meteorites, and related materials that are possibly of impact origin; and experimental research on the mechanics of impacting objects.

In the new studies, large-scale diagrams will be prepared of specific areas on the moon that have been selected by NASA as landing sites for space vehicles. In order to gain all possible geologic information in single and also in stereoscopic photographs, existing methods for taking lunar photographs will be supplemented by several lines of investigation.

For example, during the past 4 years Survey geologists have been investigating two types of terrestrial crater that probably have lunar equivalents—meteorite impact craters and volcanic craters. Although they differ in the mechanics of formation, in subsurface structure, and in certain surface characteristics, these two types of craters can be superficially similar. A detailed understanding of their formation should make it possible to produce valid photogeologic interpretations of their lunar counterparts.

This research is also of fundamental importance in any photogeologic analysis of the history of the lunar crust. Much valuable information is expected to be gained, too, from comparisons of earth materials in the vicinity of known craters with target rocks purposely subjected to very high velocity impacts at NASA's Ames Research Center, Moffet Field, Calif.

Tektites, meteorites, and related materials found on earth will be studied to determine what they are made of and to seek new evidence on where, when, and how they originated. Considerable knowledge has been gained about meteorites already, but the origin of tektites, those mysterious bits of pitted, rounded, glassy material found in many parts of the world, is still highly controversial. Some of the other matters the Survey scientists hope to pursue include investigation of the nature and flight time of particles in space and investigation of the nature of objects most likely to be found on the moon and the part they play in altering the face of the moon.

Dental Survey Results Reported by Education Council

Results of the most extensive survey of dentistry ever made in the United States were announced recently. Carried out by the American Council on Education, the 2-year survey was financed by grants from the W. K. Kellogg Foundation, the Rockefeller Brothers Fund, the Louis W. and Maud Hill Family Foundation, and the American Dental Association.

John A. Perkins, president of the University of Delaware, was chairman of the commission that directed the study, which was established to "assess the achievement, resources, and potentialities of dentistry with a view to determining the desirable areas of future growth and development." The survey identified four of the nation's major dental problems.

The American people generally set an astonishingly low priority on dental care.

There is an increasing need for more dentists to care for the nation's burgeoning population.

Despite the country's great wealth, some of its citizens are unable to pay for the comprehensive dental care that is desirable.

Even more extensive use must be made of the auxiliaries in the dental field—the dental hygienist, the dental assistant, and the dental laboratory technician.

The largest financial item in the recommendations of the survey was that for the program concerned with dental care of children. It is estimated that the program urged would cost $120 million the first year, leveling off within 12 years to an annual expenditure of $940 million.

In the area of dental research, the commission suggested that present funds, about $45 million, be increased to $1 billion.

News Briefs

Vassar centennial: science and society. "The Growing Political Role of the Academic Scientist" was examined by Bentley Glass of Johns Hopkins University in the opening address of a conference on science and society being held today and tomorrow at Vassar College. This Conference on the Natural and Social Sciences is the first of three major conferences planned to celebrate Vassar's centennial year. Others on the 2-day program are Ernest C. Pollard and Donald W. Taylor of Yale University, and Ernest Nagel of Columbia University.

* * *

Health group visits U.S.S.R. A team of six American scientists left on 12 October for the Soviet Union to survey progress in the field of maternal and child care. The 30-day mission is sponsored by the U.S. Public Health Service's National Institute of Neurological Diseases and Blindness. A group of Russian specialists will make a similar study in this country at a later date. Members of the U.S. group are: Stewart H. Clifford, Allan C. Barnes, Katherine Bain, Bernard G. Greenberg, Edith L. Potter, and Fred S. Rosen.

* * *

Yale sesquicentennial. The Yale University School of Medicine celebrated the 150th anniversary of its founding with a 2-day sesquicentennial program, 28–29 October. Heading the list of distinguished speakers were Sir Howard Florey, Nobel laureate from England, and Lloyd G. Stevenson, noted medical historian and dean of medicine at McGill University in Canada. Some 1500 guests attended.

* * *

Nuclear testing in space. The Atomic Energy Commission has announced the establishment at Los Alamos, N.M., of an experimental ground-based station for studying one of the methods which might be used to detect nuclear detonations in near space. The station's equipment, developed by the Los Alamos Scientific Laboratory, will test an atmospheric fluorescence detection technique that has been proposed for

inclusion in the world-wide network of nuclear test detection stations being discussed in Geneva. The new device uses a narrow band filter and an optical detector mounted behind a wide angle lens to detect visible fluorescence from a nuclear explosion.

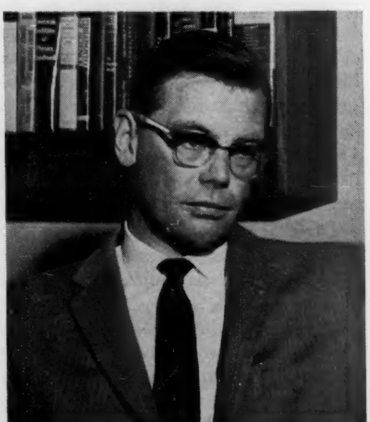
* * *

Harvard nutrition building. Ground was broken on 19 October for the new four-level nutrition research building to be erected in Boston by the Harvard School of Public Health. The building has been made possible through a gift of $102,600 a year for 10 years from the General Foods Corporation.

Scientists in the News

Massachusetts Institute of Technology is establishing a department of nutrition, food science, and technology that will be headed by **Nevin S. Scrimshaw**, director of the Institute of Central America and Panama and regional adviser on nutrition of the Pan American Health Organization, regional office of the World Health Organization. The new department, which is formed around the existing food technology department, will conduct a greatly expanded program of research and teaching in nutrition. Scrimshaw, who is at present an adjunct professor of public health nutrition at Columbia University and a visiting lecturer at the Harvard School of Public Health, will assume his duties at MIT on 1 August 1961.

Executive officer of the new department will be **Samuel A. Goldblith**, who has been associated with the department for many years and who has served as acting head since the death last September of Bernard E. Proctor.



Nevin S. Scrimshaw

Richard W. Vilter of the University of Cincinnati has received the $1000 Goldberger Award, jointly presented each year by the American Medical Association and the Nutrition Foundation, for a long-term study of the causes of anemia in the United States. In his award address, Vilter said that his investigation indicates that only about 4 percent of anemia in the United States is caused by deficiencies of vitamin B_{12}, folic acid, or vitamin C. A more important cause—responsible for 18 percent of the anemia observed at Cincinnati General Hospital, the site of the 3-year survey—is iron deficiency due to chronic loss of blood. An additional 78 percent is caused by other factors "unrelated" to nutrition. As a result, Vilter holds that it is medically wrong to prescribe vitamins routinely for anemia.

N. Rashevsky, professor and chairman, Committee on Mathematical Biology, University of Chicago, is spending 5 months in Italy as research consultant in mathematical biology at the University of Genoa.

Louis Levin, former head of the Office of Institutional Programs for the National Science Foundation, has joined the faculty of Brandeis University as its new dean of science. Levin, known for his work in the life sciences, also assumes the post of associate dean of faculty and chairman of the School of Science Council at Brandeis. In addition, he will function as the university's director of academic grants.

The award winners at the recent annual meeting of the American Institute of Biological Sciences included the following two scientists.

Janet R. Stein, instructor in the department of botany and biology at the University of British Columbia, who received the Darbaker Prize of the American Botanical Society of America for "meritorious work in the study of algae based primarily on papers published during the previous two calendar years."

Robert Ornduff, graduate student at the University of California, Berkeley, who received the American Society of Plant Taxonomists' George R. Cooley Award for the "best taxonomic paper presented at the annual meeting of the society." Ornduff has recently been appointed assistant professor in the department of biology at Reed College, Portland, Ore.

Alan L. Leiner, formerly chief of the digital systems section of the National Bureau of Standards, has recently joined the International Business Machines research organization as manager of machine organization at the Mohansic Laboratory. He is being joined in his new assignment by three other former members of the National Bureau of Standards, **A. Weinberger, J. L. Smith**, and **W. A. Notz**, who had been associated with him.

Stephen Rothman has retired from his post of professor and head of the section of dermatology in the department of medicine at the University of Chicago. As professor emeritus he will continue to conduct research work in the Argonne Cancer Research Hospital, which is operated by the university for the Atomic Energy Commission. He is succeeded by **Allen L. Lorincz**, associate professor of dermatology at the university since 1957.

Scott Adams has taken up his duties as deputy director of the National Library of Medicine. Formerly librarian of the National Institutes of Health, Adams has been serving since 1959 as director of the Foreign Science Information Program of the National Science Foundation. In his new position he is responsible for the development and operation of extramural grant programs in support of activities in the field of medical communications and medical librarianship.

He has the assistance of **Estelle Brodman**, who has relinquished her post as the chief of the Reference Division after 11 years of service. **Robert B. Austin** is now serving as acting chief of the Reference Division.

David L. MacAdam, research physicist and department head at the Eastman Kodak Company, is the new president-elect of the Optical Society of America. He will assume this title in January 1961 and take office as president in January 1962. **Wallace R. Brode**, former State Department science adviser and a past president of the AAAS, is now president-elect and will take office as president next January. **James G. Baker** of the Harvard College Observatory is the incumbent president.

Laurence E. Strong, professor of chemistry at Earlham College and director of the Chemical Bond Approach Project, has left for a 3-month visit in South Africa and parts of Central

Africa. He will explore science education programs in Africa and discuss with teachers and others the various course-content improvement projects in the United States. The trip is sponsored jointly by the United States–South Africa Leader Exchange Program, the African-American Institute, the Carnegie Corporation, and the National Science Foundation.

Harold Orlans, formerly director of studies for the White House Conference on Children and Youth, has been appointed to the Brookings Institution staff to conduct a study of the impact of federal programs on higher education, particularly on the quality of instruction. The study is being supported by a contract with the U.S. Office of Education. Before his White House Conference assignment, Orlans served as chief of the National Science Foundation's foreign science section.

Willem D. Malherbe of the faculty of veterinary science in Onderstepoort, South Africa, has accepted an appointment as visiting professor of clinical laboratory medicine at the University of Pennsylvania's School of Veterinary Medicine, effective 1 October.

Father **Francis N. Glover**, a Jesuit priest who is a physicist at the Boulder Laboratories of the National Bureau of Standards, left in mid-September for 10 months in the Philippine Islands, where he will conduct research in upper-atmosphere physics at Manila Observatory (Baguio) and at the Far Eastern University in Manila.

Jacob Sachs, professor of chemistry at the University of Arkansas, has just returned from 6 months as visiting professor of biochemistry at the medical school of the University of El Salvador and consultant to the Salvadorean Nuclear Energy Commission. His mission was conducted under the direct technical assistance program of the Division of Science Development, Organization of American States.

A. V. S. de Reuck, former assistant editor of *Nature*, has been appointed deputy director of the Ciba Foundation for the Promotion of International Cooperation in Medical and Chemical Research, London.

M. P. Cameron has returned to the Ciba Foundation as scientific assistant and librarian after 5 years in the United States.

The annual Thomas William Salmon Lectures, the outstanding American psychiatric lectureship, will be delivered on 5 December at the New York Academy of Medicine by **Harry F. Harlow**, research professor at the University of Wisconsin since 1930.

J. Ernest Wilkins, Jr., mathematician and an authority on nuclear reactor theory, has joined General Dynamics Corporation's General Atomic Division in San Diego, Calif., as assistant chairman of the theoretical physics department at the John Jay Hopkins Laboratory for Pure and Applied Science. Previously Wilkins served as manager of research and development at Nuclear Development Corporation of America, White Plains, N.Y., where he directed fundamental and applied work on nuclear reactor shielding, reactor core physics, reactor dynamics, and new fuel element concepts. A major part of his work has been in the area of the penetration of matter by neutrons and gamma rays.

John O. Corliss, associate professor of zoology at the University of Illinois, is on sabbatical leave for 1960–61 and is serving as honorary research associate in the department of zoology at University College London, London, England.

David K. Cheng and **Mark T. Ma** of Syracuse University's electrical engineering department were named award winners at the recent National Electronics Conference for their paper, "A new mathematical approach for linear (antenna) array analysis."

Glen Wade of the Raytheon Company was also named an award winner for his tutorial paper, "Parametric amplification with solid-state materials and with electron beams."

Henry B. Linford, professor of chemical engineering at Columbia University, has received the 1960 Edward Goodrich Acheson Gold Medal of the Electrochemical Society in recognition of his distinguished service to the society and for his contributions to education in electrochemistry.

Leon J. DeMerre, former senior scientist with the Department of Hygiene of the State of New York, has been named head of the food and drug laboratories in the scientific department of Joseph E. Seagram and Sons, Inc., New York.

John B. Newkirk, for 9 years research associate in the department of metallurgy and ceramics at the General Electric Research Laboratory in Schenectady, N.Y., has accepted an appointment as professor of chemical and metallurgical engineering at Cornell University. The new appointment is connected with the Materials Science Center now being established at Cornell.

A $4-million program in materials science, recently announced by the University of Pennsylvania, will be directed by **John N. Hobstetter**, professor of metallurgical engineering. The research program is to be conducted for the Advanced Research Projects Agency of the Department of Defense.

Recent Deaths

Henry B. Froning, South Bend, Ind.; 76; chemist and dean emeritus of the College of Science at the University of Notre Dame; joined the faculty in 1920 as a chemistry professor and was head of the department of chemistry and chemical engineering in 1940, when he was appointed dean; retired in 1943; 18 Oct.

Charles A. Holden, Concord, N.H.; 88; former dean of Dartmouth College's Thayer School of Civil Engineering; was a professor at Dartmouth from 1901 until he retired in 1937; was also a hydrographer for the U.S. Geological Survey from 1900 to 1904 and served as a New Hampshire state engineer from 1916 to 1937; 12 Oct.

Abram Joffe, Leningrad, U.S.S.R.; 80; physicist member of the Soviet Academy of Sciences whose work contributed largely to the launching of his country's sputniks; specialized in semiconductors; was instrumental in the establishment of important research centers throughout the Soviet Union, including the Physico-Technical Institute of the Academy of Science, which he helped found in 1951; 13 Oct.

Walter A. Rukeyser, Montreal, Canada; mid-60's; mining engineer and geologist, formerly of New York; specialist in the mining of asbestos; wrote *Working for the Soviets: An American Engineer in Russia*, published in 1932; 19 Oct.

Margaret Storey, San Francisco, Calif.; 60; Stanford University zoologist; assistant curator, zoology, Natural History Museum, was the only woman in the country officially registered as a timer of track events; 18 Oct.

Book Reviews

The Enlargement of the Presidency. Rexford G. Tugwell. Doubleday, New York, 1960. 508 pp. $6.95.

The Presidency of the United States is the highest secular office on earth. The personal power of the President of the United States, exercisable by him alone, without control by any other authorized person or court, is greater than that of the Prime Minister of Great Britain (even when the Cabinet is with him) and greater than that of Khrushchev, First Secretary of the Communist Party of the Soviet Union and Premier in the constitutional machinery of that nation. In spite of this depth and scope of power, the awful and dangerous responsibility is confided to one man and only one man; and, again in spite of this, the method of selection is such that Tugwell believes only six out of more than 30 Presidents have been creatively equal to their obligations.

These are the conclusions that emerge from this diligent and luminous study of the evolution of the Presidency, properly entitled *The Enlargement of the Presidency*. My own phrase, the "engorgement" of the Presidency, is designed to suggest, more roughly, the grave problem in statecraft which Tugwell has consciously raised. Can any one man possibly do the job?

Tugwell shows how the apparently meager clauses of the Constitution regarding the duties and powers of the President have been bodied forth, during 170 years, by the genius and enterprise (sometimes not by the *brain* but by mere *instinct*) of the strong Presidents until the President's role in the government of the United States and in American leadership in the world would cause the Founding Fathers to gasp at their immensity. For, today, the President has become the Chief Executive over a tremendous apparatus of officials and functions; the Chief Diplomatist and Guardian of the Security of the Nation, external and internal; the Chief Legislator, in that the Congress awaits and works on the program of legislation that emanates from him, affirmed by his power to veto, to strike down what he does not like; National Planner of economic progress; Social Mentor, to commend to the nation a better social ethic; Party Chief, so that he may use party organization to commend and manipulate into effectiveness the talent he possesses; Chief of State, to symbolize the nation's majesty and to educate the millions who are but tyros in the comprehension of what living in the fellowship of a nation means.

Tugwell unfolds the intermittent stages, the leaps forward, the backsliding, in this staggering evolution by identifying the nodal points in the general history of the United States at which the man's character and talents have been called forth, in "Presidential moments," to solve and to ward off disasters, to meet moral commitments, to foster progress. The facts are abundant, the analysis perspicuous and telling. Washington, Jefferson, Monroe, Jackson, Polk, Lincoln, Cleveland, Theodore Roosevelt, Woodrow Wilson, and Franklin Delano Roosevelt are the conspicuous "greats." Their persons and tactics proceed from a little land of rural settlements, as isolated from the world as was naturally possible, through the conquest and settlement of a subcontinent, to a new economy and complete immersion in the moral life of the whole world.

The three rules of action. This colossal enlargement of the office of President was accomplished under three impulses—The Rule of Necessity, The Rule of Restraint, and the Rule of Responsibility—in Tugwell's formulation. These rules are created (or not) by the Presidents for themselves and interpreted by each, alone, for himself.

The Rule of Necessity means that a President himself may decide and command whatever he individually deems necessary to solve a national crisis, especially when Congress is not helpful, whatever may be the words or silences of the written Constitution. The courts will almost certainly support the action, if his action is legally challenged. Congress will almost certainly accept the decisions and actions. Thus, Jefferson purchased Louisiana; Polk contrived the rape of Texas; Lincoln suspended habeas corpus and emancipated the slaves by proclamation; Cleveland broke the Pullman strike in Chicago; Theodore Roosevelt intervened in the anthracite strike, manipulated the legalities for the Panama Canal, sent the U.S. fleet around the world, to overawe the world and especially Japan; Woodrow Wilson instituted many executive measures during World War I; F. D. Roosevelt invented Lend Lease and dozens of other devices for welfare and victory.

The Rule of Restraint emerges from the constitutional arrangement that the powers of the Congress, the Judiciary, and the Executive Branch are separate: to each his own. The President, even following the Rule of Necessity and that of Responsibility, must be prudent and respectful of the rights of the other branches: as Washington said, it is a government of accommodation as well as of law, and he ought not stretch his own power, or relax it, unless compelled "by imperious necessity." This is respect for checks and balances, and of course, Congress has the power to enact legislation, provide funds, and raise taxes. But it imposes on the President the most wearing task of meeting Congress in an unending "cold war" for the initiative in leadership and the triumph of his will.

The third rule is that of Responsibility. It means the assumption by the Presidency, as a charge on his conscience and effort, of what Theodore Roosevelt called the "stewardship" of the nation, for its welfare and survival. This is responsibility effectuated not merely by *post facto* activity supplementary to a laissez faire society, but by the leading and guiding introduction of a national vision to the nation as a whole, supplied by the President. For he is the one elected official who is directly appointed by the nation acting as a single electorate. Congress is split many ways by its dispersed electoral districts. The President is the nation's mentor; its educator; its unifier; the planner of its civilization so far as government can and does contribute to this. Congress looks homeward too often and too agonizedly to assume the

elan of leadership of the national society of Americans.

Is there a remedy? This clear conclusion emerges from the abundance of facts and analysis and documentation: the responsibilities of the Presidency are far too big for one man alone. All the millions of official and the conciliar devices (the growth of which Tugwell sketches in) around the President do not assist him to perform the duties which he alone, the political leader, charged alone by the constitution with responsibility, must perform or, to the nation's direst peril, leave undone. Moreover, the method of election has become unsuited to the discovery of the qualities of political leadership. Is this truly the best we can do in a choice from among 23 million male Americans between the prime ages of 35 and 55? The lesson is not only clear that the unitary Presidency and the method of selection are undesirable, but Tugwell positively draws this conclusion. Furthermore, though his reconstructive proposals are not presented in this book, he firmly advocates a plural or collective executive. He observes that no other great democratic nation has a single executive.

The difficulties of political science as science. The reader of Tugwell's book will realize that only in occasional and marginal situations can Tugwell, or any political scientist, present his findings in a quantified form. He can say that in Washington's day there were only 2000 officials to be supervised by the Chief Executive and that today the President must supervise and animate 1000 times as many. But such facts do not carry the conviction that change is needed, because they do not reveal (they actually obscure) the complexities of the data of decisions, the torture, perplexity, and agony of resolving to act. It is not possible to present in a quantified form the true weight and difficulty of the Presidential burden, the insufficiency of one man's mind and conscience to grapple with his tasks and advisers. The gravest facts are imponderable. They are to be understood only by scientific immersion over many laborious and imaginative years.

The unfortunate result is that talented insight, such as one finds in this book, can be obliterated by any vulgar idolator of things as they are. It is painful to change one's habits, especially if the critic is personally contented with his situation. Thus, any crude journalist can cancel the effect of the most diligent political scientist simply by attacking the scientist's constructive proposals, because *his* (the journalist's) personal aims and purposes do not require them. He need not even attempt to weigh the mass of evidence: he can blind the reading public to the new facts by his prejudiced sneers. In a *New York Times Book Review* notice on 25 September 1960, this happened to Tugwell's reconstructive suggestions and to my more explicit proposals (a President with 11 executive Vice-Presidents elected as one team), made in my book, *The Presidency: Crisis and Regeneration* (University of Chicago Press, 1960). Instead of revealing the findings of Tugwell and Finer, the reviewer merely cried out "Sacrilege!" It is a great pity that such treatises, full of interest, fascinating, and essential to the common weal, are obscured to the public mind by such devices.

HERMAN FINER
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Aktuelle Probleme der Ernährung. vol. 1. J. C. Somogyi, Ed. Karger, Basel, Switzerland, 1960. vi + 224 pp. Illus. F. 34.

Until recently Switzerland had no institute devoted exclusively to nutritional research. Therefore, the Green Meadow Foundation established such an institution, and it was inaugurated 18 April 1959. On this occasion Swiss and foreign scientists presented papers directly or indirectly connected with present trends in nutritional research; these papers have been published under the editorship of the director of the Institute for Nutrition Research in Rüschlikon-Zürich, J. C. Somogyi. Somogyi contributed an interesting paper entitled "On the antimetabolites of thiamin"; his paper also sheds new light on the topic ably discussed by A. von Muralt in the paper "On the role of thiamine in the metabolism of the peripheral nerve system."

In a short book review it is impossible to deal with the great variety of subjects contained in this first volume of the institute's publication series. A few remarks must suffice to indicate the scope of this volume. The paper by J. Yudkin, "Man's choice of food" is not satisfactory, in my opinion. While one may agree with Yudkin that the existence of a specific "food instinct" has not been proved in higher animals or in human beings and that, in general, correct food habits cannot be explained satisfactorily by assuming they resulted from the experience of numerous generations, his alternative hypothesis of satiety cannot be accepted since neither animals nor human beings know when to stop eating. Clive M. McCay uses a more adequate and individualistic approach in his very instructive paper, "Nutrition of older people." Only recently has this subject been given deserved attention. McCoy shows how the food habits of the elderly properly reflect changes in nutritional requirements, and he raises the pertinent but not yet fully understood question of how the body adapts itself within certain limits to changes in food supply. The excellent paper, "Foreign substances in foodstuffs," by F. Eicholtz is of great interest, and so is the paper by J. Kuprianoff, "Radiation preservation of food." Kuprianoff confirms the findings made by research workers in the United States that radiation doses adequate to prevent spoilage do not produce induced radioactivity or any other form of toxicity, but that organoleptic changes which make some irradiated foodstuffs less acceptable are produced. Since whole cells play an important part in the transport and metabolism of nutrients, the paper by G. v. Hevesy, "Radioactive labeling of cells," will be read with great interest. It shows that, by marking specific molecules, such as hemin or DNA, with radioisotopes, one can label entire cells, such as red or white blood corpuscles, and in this way follow their life cycle in the living organism more exactly than by any other method.

FRANCIS JOSEPH WEISS
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An Introduction to Linear Programming and the Theory of Games. S. Vajda. Methuen, London; Wiley, New York, 1960. 76 pp.

Part 1 of Vajda's monograph provides a lucid introduction to the main ideas of linear programming, a mathematical discipline concerned with the maximization or minimization of a linear function of non-negative variables subject to linear constraints (equations or inequalities). The formulation of a simple production-scheduling problem serves as an introduction. Then a method of solution is developed for a special category of linear programming

situations, called transportation problems, in which one seeks the cost-minimizing pattern for transporting some commodity from several origins (each with a limited supply) to several destinations (each with a fixed requirement); in general, the cost of shipment per unit differs for different origin-destination combinations.

Turning next to the general linear programming problem, the author gives an exceptionally clear account of the basic computational procedure (G. B. Dantzig's *simplex method*), built around a detailed discussion of an illustrative two-variable problem. Here I regret that the algebraic analysis was not more explicitly supplemented by the corresponding geometrical picture: the procedure involves hopping from vertex to adjacent vertex of the multidimensional, convex polyhedron described by the constraints, always in the direction in which the function to be maximized (minimized) is increasing (decreasing). The final topic discussed is duality; in solving a problem by the simplex method, one also automatically solves (by another method) a "dual problem," the data array of which is obtained from that of the original problem by interchanging rows and columns. The relationship between original and dual problem is described in some detail, but the formal proof of the resulting duality theorem is relegated to an appendix which, unfortunately, is marred by typographical errors.

Part 2 deals with the so-called theory of games, that is, with the selection of optimal behavior versus intelligent opponents. Most attention is paid to the classical case in which two players, each with finitely many strategies, have diametrically opposed interests; a *solution* of a game is defined, and it is shown how, in general, solutions do not exist unless probabilistic mixtures of strategies are admitted. The author then describes the reduction of such a game to a linear programming problem and its dual; the existence of a solution (using probabilistic strategy mixtures) is deduced from the duality theorem of part 1 (an independent proof is given in an appendix), and the simplex method can be used to compute the solution. One subsequent section deals with games having infinitely many strategies, another with games in which the players are not directly opposed.

The author has been remarkably successful in giving a lively and accurate treatment of so much material, including several topics not mentioned above, in so few pages. No advanced mathematics is employed, and the book is recommended to all members of the scientific community willing to exert the requisite concentration. The reader should bear in mind, however, that the simple examples chosen for expository purposes give no idea of the multiplicity of real-life situations in which the subject matter has proved of value, or of the degree of complexity of these applications to realistic problems.

A. J. GOLDMAN

National Bureau of Standards, Washington, D.C.

A Bibliographical Checklist and Index to the Published Writings of Albert Einstein. Compiled by Nell Boni, Monique Russ, and Dan H. Laurence. Pageant Books, Paterson, N.J., 1960. 84 pp. $6.

This check list is divided into three parts: scientific writings, general writings, and selected interviews. Within each of the parts the material is arranged chronologically, the order being determined by the year and month of the first publication regardless of the language in which the specific work was first published. Revised or translated texts are attached by subnumbers to the original publication, regardless of when later publication occurred.

In preparing the bibliography the compilers consulted the following works: *Albert Einstein: Philosopher-Scientist* (1949; ed. 2, 1951) edited by Paul A. Schilpp and the Einstein bibliography (1937) by E. Weil. This material has been augmented and revised; 607 items are listed.

Convention Decisions and Voting Records. Richard C. Bain, Brookings Institution, Washington, D.C., 1960. xi + 327 pp. Appendixes.

This is a companion volume to *The Politics of National Party Conventions* (Brookings Institution, 1960). It seeks to supplement that study of the presidential nominating process by providing an account of the convention proceedings of the two major parties since 1832 and a record of important convention votes. Each convention is introduced with a brief description of the political situation existing at that time in the United States.

Medical Helminthology. John M. Watson. Baillière, Tindall and Cox, London; Williams and Wilkins, Baltimore, Md., 1960. viii + 487 pp. Illus. $15.50.

As we become increasingly aware of, and concerned with, world-wide problems of human health we will inevitably pay increasing attention to the worms as causes of human debilitation, suffering, and death. A large proportion of the world's population is infected with one or more parasitic worms, and many millions of people suffer as a result. The penalty for the losses suffered falls upon all of us.

It is Watson's intention to present, relatively briefly, essential and up-to-date information about the worm parasites of man, to point out their importance to man's health, and to call attention to gaps in our knowledge about them. There has been a need for such a book, and this book meets the challenge.

About one half of the text deals very effectively with such basic things as the nature of parasitism; life cycle patterns; parasite physiology, ecology, and transmission; resistance and immunity to infections; diagnosis, prevention, and treatment of parasite infections; pathogenesis of infection; and so forth. In these sections the author succeeds in achieving brevity without falling into a recital of dry generalities. Important and pertinent examples are usually cited to illustrate his points.

The remainder of the book treats the worms according to taxonomic groups. The morphology and organ systems of each group are described, the larger taxonomic groups are characterized, and then individual species are dealt with. Usually only a few pages could be devoted to a single parasite—for example, 8 pages are devoted to *Ascaris*—but this is sufficient to present a surprisingly large amount of carefully selected information. All the illustrations are comparatively simple line drawings, stressing salient points of anatomy and important stages in the life history. Recognition characters and comparisons of related species are emphasized. Some readers may find these drawings crude and somewhat inadequate.

This book is written in an admirably clear and unpretentious style which is in refreshing contrast to some of the other texts on the subject. There are very few references to literature, but a text of this sort needs none. The

appendix includes a list of general references, mostly texts and monographs.

This book will probably be most useful to students of medical helminthology and should serve admirably as a text for this subject. It will also serve as a guide for physicians who occasionally encounter patients with worm infections.

LOUIS J. OLIVIER
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Aquatic Phycomycetes. Frederick K. Sparrow, Jr. University of Michigan Press, Ann Arbor, ed. 2, 1960. xxv + 1187 pp. Illus. $22.50.

With the possible exception of a few specialists in the limited field involved, mycologists and others interested will be surprised to find that the subject of aquatic Phycomycetes requires a volume of over 1100 pages for adequate presentation. Equally interesting is the fact that the present edition represents a 50 percent increase in size over the first edition (1943) which at that time was considered to be "a notable achievement."

Aquatic fungi belong largely to the class Phycomycetes, the most primitive of the Eumycetes, or true fungi, although each of the other fungus classes does contain some species which are aquatic or which live on aquatic substrata.

This standard work brings together information available through 1 January 1955 on all phycomycetous fungi occurring in fresh or marine waters. It does not include most of the Peronosporales (downy mildews) or the Entomophthorales, which develop on strictly terrestrial hosts or substrates. These latter fungi have been adequately treated in other monographs. The author has added to this edition those species of *Pythium* and *Phytophthora* known to occur as water molds, the genera of the Saprolegniaceae, and citations of new species in the family published since Coker and Mathew's monograph (1937). Also included are all new taxa in the other pertinent groups which have been described since the publication of the first edition. Literature references appearing subsequent to the date limit (1955) have been included in the bibliography. Similarly, new taxa and the results of recent investigations have been noted in footnotes or added at appropriate points under the heading "Recently described taxa." The total number of taxa involved is impressive—8 orders, 24 families, 152 genera, and 781 species—in contrast to the number that are given in the first edition—7, 21, 112, and 475, respectively.

The original plan of presentation has not been materially changed in the present work. A comprehensive introduction considers general phases of the subject including phylogeny and the relationships of the several groups, geographic distribution, hydrobiological aspects, methods of isolating and culturing the fungi as well as their preservation in permanent collections, and finally a key to the orders. In the consideration of the orders, attention is given to morphology, methods of development, reproduction, cytology, and parasitism. A detailed systematic account of each family, genus, and species is given with keys for each family and genus. There are technical descriptions of each taxon with notes on substrates, collectors, distribution, literature references, and critical comments on taxonomic points.

Hidden away in the text are two new genera and a considerable number of new species and new combinations, all properly set up to conform to the International Code of Botanical Nomenclature. Listing these changes on a single page would have been very helpful to those concerned with the nomenclatorial aspects of the subject.

A carefully prepared list of substrata is provided following a systematic arrangement of the plant and animal hosts or organic substances involved. A bibliography of over 1200 entries, practically all of which the author has reviewed, points up the large number of workers in many countries who have contributed to the general subject. A general index to technical names concludes the book.

In this compendium the author has presented a complete and well-rounded account of the subject of aquatic fungi. It is an authoritative and scholarly work, and one which all who are in any way concerned with these fungi will need to have at hand at all times for ready reference.

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Reports

Glass Insulated Platinum Microelectrode

Abstract. Microelectrodes for electrophysiological use have been prepared easily and quickly by electrolytically sharpening platinum iridium alloy wire and coating with molten glass. The desirable combination of the electrical characteristics and strength of the platinum iridium wire with the exceptional durability of glass insulation has long been known, but earlier methods of fabrication were difficult and tedious.

Electrophysiological changes in single neurons are often most easily detected with an insulated core metal microelectrode. This type of electrode usually has a much lower noise level and a better high frequency response than the fluid-filled micropipette. Many designs have been proposed for making metal microelectrodes, but in spite of the investigations of the mechanical, electrical, and geometrical properties (*1*), the designs are usually determined empirically. The considerations that enter into the design can be more easily understood through a short discussion of the advantages and defects of the currently popular electrodes.

A stainless-steel electrode can be made cheaply and readily in large quantity. It appears to record satisfactorily in certain situations (*2*). It is a strong electrode, but the varnish insulation is troublesome, principally because it lacks durability. In addition, the electrode is apt to be excessively unstable electrically. The tungsten electrode recently described by Hubel (*3*) can now be made easily and features great strength, but it also suffers from electrical instability and the inadequacies of the existing varnishes. The indium-filled glass electrode of Dowben and Rose (*4*), as modified by Gesteland *et al.* (*5*), is somewhat difficult to prepare but has excellent electrical characteristics and appears to record well in a variety of situations, but its tip is easily damaged and it cannot be reworked or reused.

Platinum has always been a favorite electrode metal of electrophysiologists and has been used successfully in a wide variety of situations. Wilska (*6*) has described a sharpened platinum iridium alloy wire microelectrode insulated with glass which seems to combine all the ideal features of a good microelectrode and to exclude a number of undesirable ones. It records well from electrophysiological units, is quite selective, possesses high mechanical strength, and the insulation is outstanding. Wilska's method of manufacture is to grind the wire to a point and then shrink a heated glass capillary over it. This requires a high degree of skill and elaborate equipment both in pointing of the wire and in coating it with glass. We have worked out a method for fabricating this type of electrode which requires little skill or equipment and is much less time consuming.

The technique is as follows: A length of 8 to 10 mil, 70 percent platinum, 30 percent iridium alloy wire (*7*) is straightened by passing it, while under tension, through a small flame. One end of a short length of wire is immersed in a solution of 50 percent sodium cyanide, with 30 percent sodium hydroxide added to prevent the formation of hydrogen cyanide. An electrolyzing current is applied from an a-c source between the wire and a carbon rod inserted into the bath. The initial shaping is accomplished at 6 to 10 volts a-c (root-mean-square) accompanied by vigorous agitation of the bath. A magnetic stirrer is very convenient for this purpose. Final polishing with a much smaller voltage (0.8 volt a-c) yields smooth, gradually tapering electrodes having tips less than 1 μ in diameter. Agitation is not necessary during this step. The taper is controlled by the length of the wire inserted into the bath. Repeated withdrawal of the tip from the bath is not necessary in these processes. After pointing, the electrode should be washed in distilled water, air dried, and stored until a day or so before using, at which time it should be glass coated.

This procedure is accomplished by pushing the tip through a small drop of molten glass adhering to a V-shaped electrically heated loop of 15 mil platinum wire. Corning No. 7570 solder glass is used for coating because of its extremely low working point, 560°C. Corning No. 0041 potash soda lead glass, which has a much higher working point (990°C), has also been used successfully. Although this glass is somewhat stronger, it is more difficult to obtain uniform coatings with it. The thermal expansion coefficient of the wire is about 8.5×10^{-7} cm/cm °C, and any glass with a similar coefficient would probably be suitable without cracking. The wire is pushed through the molten drop until an adequate length of it is coated. The tip may be pulled back through the drop or the shank may be pulled up through the top of the loop. The temperature of the loop must be increased as the thicker shank of the wire is inserted inside the glass drop, as the increased heat loss decreases the fluidity of the glass. The glass wets the platinum iridium wire and covers the entire electrode surface, including the tip, with a thin insulating coat. However, to record properly, the extreme tip must be bare of glass, and a procedure must be employed to remove the right amount of insulation and provide the best interface between the electrode

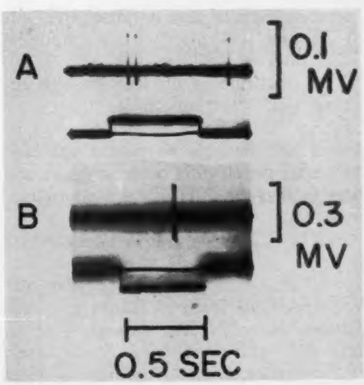

Fig. 1. Single unit action potentials recorded with the same platinum iridium electrode from ganglion cells in the retina of a goldfish (A), and the retina of a frog (B). In (A), upward step in lower trace indicates the duration of illumination used for stimulus. In (B), downward step indicates duration of interruption in illumination used for stimulus.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

and the tissue. Since the glass coating is thinnest at the tip, where an applied voltage has its strongest gradient, preferential breakdown of the insulation at this location is easily done electrically. The best electrical stability and lowest impedance may be obtained by coating the exposed area with platinum black. Fortunately, the two procedures may be combined into one by utilizing the platinizing voltage as the insulation rupturing voltage. The platinizing bath is a 1 percent solution of platinous chloride (stronger solutions appear to be detrimental to the coating). Current from a 15-volt d-c source in series with a 1-megohm resistor is passed for 15 to 30 seconds between the electrode and a platinum wire in the solution, the electrode being negative. A stream of tiny bubbles from the tip indicates a good electrode. Bubbles elsewhere indicate that the insulation is leaky and that the electrode needs to be recoated with glass. After electrodes have been used in biological material, they should be cleaned by bathing them overnight in distilled water.

Electrodes of this type have recorded successfully from the ganglion cells of the vertebrate retina, the optic nerve of the squid, mechanoreceptors on the antennae of mosquitoes, and many others. Some of the neurons recorded from were sensory nerve fibers and ganglion cells less than 10 μ in diameter for which most other types of electrodes are too noisy. Neurons giving impulses of 40 μv or more could easily be isolated from the surrounding neural activity. Figure 1 shows records made by using the same electrode first in the retina of a goldfish and then in the retina of a frog. With our recording system the electrode usually has a noise level of 20 μv and will discriminate impulses larger than 40 μv.

The electrode is durable enough to record well after penetrating the cartilaginous "skull" of a squid (*8*), and it should also be able to record successfully after penetrating other tough structures such as the dura of the mammalian brain (*9*).

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27 July 1960

Isolation of Uridine Diphosphate–Glycosyl Compounds from the Slug

Abstract. An examination of the acid-soluble nucleotides of *Limax maximus* Linné revealed, among others, several uridine diphosphate–glycosyl compounds. Nucleotides isolated and identified were the uridine diphosphates of glucose, acetylglucosamine, and acetylgalactosamine.

Numerous reports have indicated the occurrence in various snails and other mollusks of sulfated polymers (mucins) which contain one or more of the sugars glucose, galactose, glucosamine, and galactosamine (*1*). Since current research trends support the hypothesis that polymer syntheses are intermediated by nucleotide-activated precursors (*2*), it seemed worth while to investigate the nucleotide content of the slug, *Limax maximus* Linné (*3*).

Nucleotides were extracted from 24 slugs (156 g) by homogenization with 150 ml of ice-cold 10-percent trichloroacetic acid in a Waring blender. An equal volume of ethanol was added, the precipitate was centrifuged off and discarded, and the supernatant solution was treated essentially by procedures previously described (*4*). Nucleotides in the extract were freed of salts by charcoal treatment (*5*) and then adsorbed onto a Dowex-1-formate column. The column was washed with 3*M* formic acid and the uridine diphosphate–glycosyl compounds were then eluted with 4*M* ammonium formate (*p*H 2.8).

Salts were again removed by charcoal treatment and the nucleotides were chromatographed on Dowex-1-formate with a linear gradient (*6*) which changed from 3*M* formic acid to 4*M* ammonium formate, *p*H 3. A single peak of the five obtained from the column contained over 80 percent (42 μmole as uridine) of the 260-mμ absorbing material. Only the material from the single large peak was further investigated. After processing by the charcoal procedure (about 25 percent recovery), the material gave 250 mμ to 260 mμ and 280 mμ to 260 mμ ratios of 0.76 and 0.42, respectively, thus suggesting the presence of uridine compounds. This material was then separated into three major ultraviolet absorbing bands by paper chromatography on Whatman No. 1 paper, with ethanol-M ammonium acetate (7.5:3, vol/vol) as solvent, first at *p*H 7.5 and then at *p*H 3.7 (*7*).

The slowest moving band contained at least 30 percent uridine diphosphate–glucose, as determined by comparing 260 mμ measurements with assay by uridine diphosphate–glucose dehydrogenase (*8*) and acid hydrolyzable glucose content as determined with glucose oxidase (*9*). The remainder of the material in the first band has not been identified.

The second band exhibited R_F values on paper chromatograms similar to known uridine diphosphate–acetylglucosamine and was found to contain acid-hydrolyzable acetylhexosamine (0.1*N* HCl/10 min at 100°C) (*10*). To determine whether or not more than one amino sugar was present, the material was hydrolyzed for 2 hours in 2*N* HCl and then was chromatographed on a 1- × 50-cm Dowex 50-H column by the procedure of Gardell (*11*). Two hexosamine-positive peaks (*12*) emerged from the column with R_F values suggestive of glucosamine and galactosamine, and were further identified as such by (i) comparison of R_F values with knowns on paper chromatograms with use of *n*-butanol-pyridine water (6:4:3 vol/vol) as solvent and silver nitrate to visualize sugar spots (*13*), and (ii) by degradation with ninhydrin by the procedure of Stoffyn and Jeanloz (*14*) to yield arabinose and lyxose, respectively.

The third, fastest-moving ultraviolet absorbing band contained a reducing compound (*15*) which has not been identified.

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24 June 1960

A Difference between Biological Effects of Gamma Rays and Heavy Ions

Abstract. When irradiated with gamma rays, *Artemia* eggs show the typical sigmoidal survival curve of a multicellular organism, with little change at low doses and an abrupt decrease in survival above a threshold dose. On irradiation with 160-Mev oxygen ions, the threshold disappears and viability can be destroyed by passage of a single energetic ion.

Gamma-ray survival curves for many multicellular organisms are sigmoidal and show an initial insensitivity to low doses. Only above a threshold does the viability drop appreciably, and then it usually falls off quite rapidly. The ability of eggs of the common brine shrimp, *Artemia salina*, to hatch after gamma-ray exposure decreases in this way with increasing dose, as shown in Fig. 1. These eggs are moderately complex. The fertilized oöcyte divides to the blastula stage before becoming encysted and laid. In this stage the egg is about 200 μ in diameter, and it must dry before further development can take place. In all the experiments reported here the eggs were irradiated in high vacuum. There was no adverse effect from vacuum treatment alone. On immersion in sea water the egg develops rapidly, and at about 48 hours the shell cracks open and an embryo encased in a membrane is released. This process, called "emergence," is inhibited by radiation, as shown in Fig. 2. After another 6 to 8 hours a free-swimming larva comes out of the membrane; this step is called "hatching."

The long plateau which indicates the accumulation of gamma-ray damage is markedly reduced if the eggs are irradiated with 40-Mev helium ions and disappears entirely when 160-Mev oxygen ions are used. The particles were from the Yale heavy-ion linear accelerator, and dosimetry was carried out by methods previously described (*1*). The exponential decrease in survival indicates that the passage of a single energetic oxygen ion is responsible for the loss of activity of an egg. The result is qualitatively similar to that of Stapleton, Hollaender, and Martin with *Aspergillus* spores (*2*) but is more spectacular.

The three types of radiation differ from each other in the spacing between inactivating events, ranging from several thousand angstroms for gamma rays, to the order of tens of angstroms for 40-Mev helium ions (240 ev of energy loss per 100 angstroms of track), to angstroms for 160-Mev oxygen ions (3800 ev per 100 angstroms, or an average of 1.3 ion pairs, at 30 ev per ion pair, per angstrom of path). The effect is not caused by over-all dose rate, since (i) fast electrons given at a dose rate of 2 Mrad/min produced the same survival curve as gamma rays at 0.275 Mrad/hr, and (ii) the threshold was lower with helium ions and disappeared with oxygen ions, although the time required to deliver the total dose in the last two cases was about the same (tens of seconds).

Four possible explanations for the loss of a threshold with heavy ions are as follows.

1) The gamma-ray curve may be interpreted as showing that either a certain number (20 to 60) or a certain fraction of functioning units in the egg must be damaged to prevent development. It might be assumed that a single fast oxygen ion might do the necessary damage. However, converting the doses in Figs. 1 and 2 to particles per unit area shows that 24 and 9 oxygen ions per square micron are needed to suppress emergence and hatching, respectively, to 37 percent of that of controls. Each cell will have been traversed on the average by many ions before inactivation. Thus, the chance that any single ion will do all the necessary damage is small, and on this assumption the survival curves with oxygen ions would still show a cumulative effect, not the exponential form found.

2) The *simultaneous* inactivation of several widely separated areas by a heavy ion might be biologically more effective than consecutive inactivation by gamma rays. This is a process which might be very important in a metabolizing system, especially at low dose rates, but it is doubtful that it was important in dried eggs.

3) If the inactivating events took place close enough together in the densely ionizing track of an oxygen ion the resultant physicochemical events might be different, and conceivably more effective. There is some evidence for this process from experiments with heavy ions on dried enzymes (*3*), and it could be operative here.

4) The most likely possibility is that if enough damage is done within some limited volume the egg will not develop. This damage can be cumulated through many "hits" from gamma rays or caused by a single oxygen ion. Presumably the dimensions of this volume are less than 1 μ. There may be several such volumes per egg.

An extrapolation of this result leads one to consider the possibility that heavy ions in the primary cosmic rays which are met with above the earth's atmosphere may produce radiological effects at low total dose levels which would not be expected from x-ray data because of threshold effects. This suggestion is contrary to the conclusion advanced by Zeman, Curtis, Gebhard, and Haymaker (*4*) from their work with microbeams of deuterons on mouse-brain tissue. *Artemia* is an unusual material, as shown by its extreme

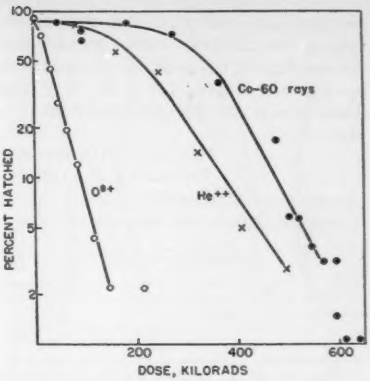

Fig. 1. Plot of the percentage of *Artemia* eggs hatched (semi-log scale) against dose for three different radiations.

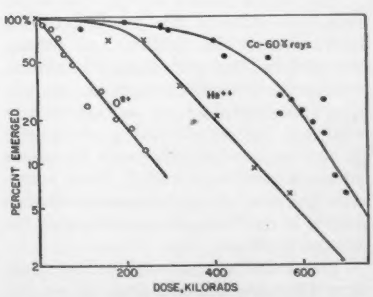

Fig. 2. Plot of ability of the *Artemia* larva to emerge from the egg (the first stage in development) against dose for three different radiations.

resistance to radiation, but the vanishing of the threshold shown by our data is a sufficiently significant phenomenon to warrant looking for it in other systems which are affected by lower dosages (*5*).

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27 June 1960

Nerve-End Recording in Conducting Volume

Abstract. When the end of a freshly cut nerve is drawn into a tube by means of a hydraulic device that serves as a holder and as an electrode, monophasic positive records of action potentials are recorded. A trailing positive phase develops, with time, after the cut. After-potentials can also be recorded by this method.

Potentials comparable in size to those recorded conventionally in oil or air may be obtained from the end of a nerve which has been drawn into a small glass tube. In this method the entire nerve is at all times completely immersed in Ringer's solution, and the potential drop occurs between a wire inserted inside the tube and an indifferent lead in the surrounding medium. This method has been used, in principle, for stimulation but apparently not for recording from nerve (*1*).

The device shown in Fig. 1 provides precise control of the position of the nerve end in its holder. The tubing, completely filled with Ringer's solution, constitutes a hydraulic pressure system. The contained fluid can be forced in or out, and the nerve moving along with it may be fixed at any point by means of screw controls *A* and *B*. These coarse and fine controls apply pressure through inserts in the Plexiglas block holding the control bulb.

Electrodes were constructed of silver wire (Birmingham and Stubs gauge 22) inserted through a length of about 15 cm of polyethylene tubing (inside diameter, 0.034 in.; outside diameter, 0.050 in.). At one end the wire extended about 1 cm beyond the tube. At the other, the wire was bent upon itself and sealed to the edge of the Plexiglas stopper *C*, which was inserted into the control bulb constructed from 10 cm of amber latex tubing (inside diameter, 0.125 in.). A second wire attached outside the end of the tube served as the indifferent lead.

Air bubbles were eliminated from the system by drawing Ringer's solution through the rubber tube and then replacing the terminal plug *D*. The polyethylene tube *E* was mounted on a manipulator constructed from rod-end bearings. Holding tubes *F* were constructed of melting-point glass tubing (inside diameter, 0.8 to 1.0 mm; outside diameter, 1.0 to 1.5 mm); the smooth cut ends were fire-polished to provide the desired size of aperture. The tubes were sorted by means of a series of brass wires of standard gauge (B & S 18 to 36). A tube with opening of appropriate size could be quickly selected by comparing the nerve diameter with the standard wires. The glass tubes were readily slipped over the silver wire and into the polyethylene tubing as needed. The silver wire was chloridized for about 2 cm at the tip before the glass tube was attached.

Records were obtained from exsected sciatic nerve or spinal root of *Rana pipiens* and *R. catesbeiana*. The preparation was grounded via the metal tubes used for circulating the water that maintained a temperature of 15°C in the bath. The end of the nerve was usually about 1 cm from the end of the wire in the tube, but changes in this distance had no observable effect on the record.

Several electrodes for stimulation and recording could be used simultaneously. A switching arrangement allowed any combination to be selected. The use of multiple indifferent leads did not seem to complicate the records. Each indifferent lead was placed near the glass tube of its companion electrode. The nerve end, oriented close to the tube opening, was drawn into the tube by release of pressure, by the fingers directly or via one of the screw controls.

Injury current was maximal immediately after the nerve had been cut with sharp scissors. The current declined with time, presumably due to narrowing of the cut end during outflow of axoplasm and the spreading of myelin over the cut end (*2*). Action currents at the distal, "healed" end and at the freshly cut proximal end of the sciatic nerve of a frog are shown in Fig. 2. Action currents were monophasic positive immediately after the cut, whether the nerve was pulled into the tube for a few hundred microns or for

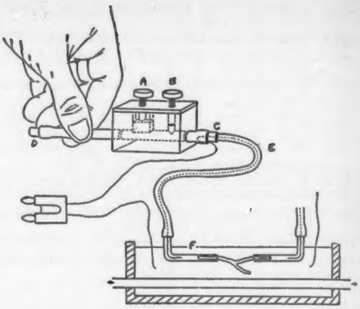

Fig. 1. Hydraulic holding and recording device for nerve end.

several millimeters (*3*). With time, after the nerve was cut, a trailing negative phase developed unless the end was left in the tube, in which case the monophasic positive record persisted (*4*). After-potentials lasted about 0.5 second and were initially positive-going, while a later negative phase developed during a train. These positive and negative phases appear to correspond, respectively, to the negative and positive after-potentials conventionally recorded with external electrodes. With passage of

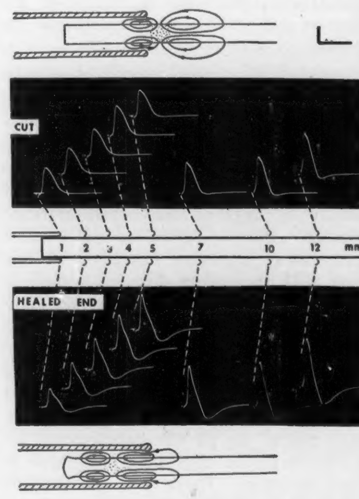

Fig. 2. Action currents recorded by means of the hydraulic holding device. The sciatic nerve of a bullfrog was prepared 8 hours before the recording was made. Upper records are from the proximal end of the freshly cut nerve, which had been drawn into the tube for the distances indicated. Diagram (top) shows the net direction of current flow outward near the nerve end. Lower records are from the distal (healed) end of the nerve, which had not been touched since the cut was made, 8 hours previously. Diagram (bottom) shows the net current flow inward during the negative phase. (Top, right) Calibration: 2 mv, 2 msec.

time after the cut, the after-potentials became smaller. At a healed end, after-potentials were absent or were negative in sign. The negativity increased during a train and was followed by a positive phase.

The sign of spike (positive with respect to the indifferent lead) and possibly the sign of the after-potentials and the injury currents recorded at the freshly cut end by this technique appear to be consistent with the sign of membrane resting and action potentials recorded by intracellular electrodes. The use of the technique may therefore result in less confusion than prevails when conventionally, externally obtained negative-upward records are compared with the intracellularly obtained observations. Less length of nerve than is ordinarily required is adequate with this method, and the inconvenience and deleterious effects of air and oil are eliminated (*5, 6*).

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6. This research was supported by grant No. B-927 from the National Institutes of Health, U.S. Public Health Service.

27 June 1960

Three γ-Globulins in Normal Human Serum Revealed by Monkey Precipitins

Abstract. Precipitating antibodies specific for three normal human γ-globulins of relatively slow electrophoretic mobility were prepared in monkeys and demonstrated by immunoelectrophoresis in conjunction with absorption techniques in which two myeloma globulins were used as absorbents.

Monkeys were selected for the preparation of antibodies to human serum proteins because antibodies prepared in a more closely related species might be more discriminating for minor antigenic differences among the serum proteins than antibodies prepared in a more distantly related species (*1*). Rhesus monkeys were immunized with normal human γ-globulin prepared by cellulose ion-exchange chromatography (*2*). Doses of 5.0 to 50 mg of γ-globulin were injected subcutaneously or intramuscularly. The first dose was emulsified in complete Freund's adjuvant; subsequent doses in incomplete adjuvant or in saline were given at monthly or biweekly intervals. Sera were analyzed by immunoelectrophoresis in agar gel used in conjunction with absorption techniques as previously described (*3*).

Figure 1 is a photograph of a stained immunoelectrophoretic agar plate showing the precipitin bands which appear when a monkey antiserum (E235) against normal γ-globulin reacts with the electrophoretically separated globulins of normal human serum, myeloma serum Br, myeloma serum Ro, and a mixture of the two myeloma sera (*4*). Figure 2 is a photograph of a stained plate showing the precipitin bands which result when the same monkey antiserum (E235) is absorbed with each myeloma serum (Br and Ro). The electrophoretic patterns of Br (1:16 dilution in saline), normal human serum (undiluted), and Ro (1:16 dilution in saline) are shown superimposed on the results of double diffusion. The left trough had been filled with E235 absorbed with Br; the right trough, with E235 absorbed with Ro.

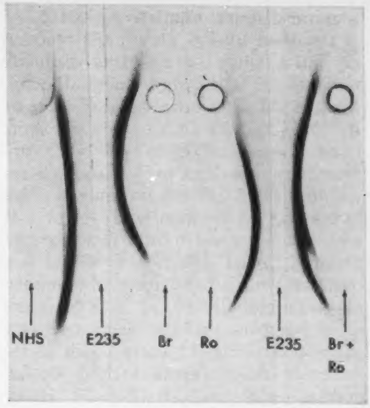

Fig. 1. The precipitin bands which appear when monkey antiserum E235 reacts with the electrophoretically separated globulins of normal human serum, myeloma serum Br, myeloma serum Ro, and a mixture of the two myeloma sera.

After E235 is absorbed by either myeloma serum (Fig. 2), the antibodies remaining no longer react with the myeloma serum used for absorption but do react with normal serum to yield a long and short precipitin band. The two long bands are asymmetrical with respect to the electrophoretically separated "slow" γ-globulins, indicating that the unabsorbed antibody in the left trough reacted with a γ-globulin (closer to the anode) of faster average mobility than the unabsorbed antibody in the right trough; these two γ-globulins are designated γ-A and γ-B, respectively (*5*). The two shorter bands are symmetrical and represent reactions of an unabsorbed antibody specific for a third γ-globulin which is designated γ-C. The precipitin reaction patterns in Fig. 2 were also obtained with γ-globulins which were considered free of macroglobulin (*2*). Thus, γ-A, γ-B, and γ-C are presumably 7S γ-globulins.

The antibody to γ-A prepared by absorption of E235 with Br was found to react also with Ro; thus, γ-A and Ro have an antigenic determinant (designated as X) in common. Antibody to γ-B prepared by absorption of E235 with Ro was found to react also with Br; thus, γ-B and Br have an antigenic determinant (designated as Z) in common. In Fig. 1, the coalescence observed when the mixture of Br and Ro react with E235 suggests the presence of antibody to an antigenic determinant (designated as Y) common to Br and Ro. That Br and Ro have an antigenic determinant in common was also indicated by other monkey antisera which were completely absorbed by either Br or Ro. Finally, the antigenic determinant on γ-C is designated as W.

Still other monkey antisera, T710 and E221, in their reactions with normal γ-globulins, yielded long, broad precipitin bands which showed splittting at the cathode or anode end, respectively, and coalescence at the anode or cathode end, respectively (*6*). Each fork of the split band could be shown to coalesce with a band formed with one of the myeloma globulins (*6, 7*). These results suggested that γ-A and γ-B correspond in two of their antigenic determinants with the two myeloma globulins Ro and Br. Thus, γ-A and Ro have determinants X and Y, while γ-B and Br have determinants Y and Z.

Accordingly, the reaction of unabsorbed E235 and normal serum, which results in the long, broad band (Fig. 1), represents the superimposed reactions of anti-X, anti-Y, and anti-Z with γ-A (XY) and γ-B (YZ), and, as would be expected, the antibodies appear to react with a γ-globulin of intermediate mobility between γ-A and γ-B. When E235 is absorbed by Br (YZ), it should contain anti-W and anti-X (Fig. 2). Since anti-Y has been removed, the reaction of anti-X with γ-A (XY) is slightly closer to the trough than when unabsorbed E235 is used (Fig. 1), and the separation of this band from the short band due to anti-W with γ-C (W)

is more distinct. Similarly, when E235 is absorbed by Ro (XY), the reaction of anti-Z with γ-B (YZ) is distinctly separate from the short band. Finally, when E235 is absorbed by a mixture of Br (YZ) and Ro (XY), only the short band corresponding to γ-C (W) appears; no antibodies to γ-A and γ-B remained. That γ-C has no antigenic determinants in common with γ-A or γ-B was also suggested by the fact that the precipitin band due to γ-C would not coalesce with a band formed by either myeloma globulin (*6, 7*). It is of interest to point out that the faster myeloma globulin Br (Fig. 1) corresponds in its antigenic determinants to the slower normal γ-globulin, γ-B (Fig. 2). However, this relationship is reversed with selected myeloma globulins which are of slower mobility than Ro and have the same two antigenic determinants as Br and γ-B (*8*).

None of three horse or three rabbit antisera when investigated in the same manner could distinguish between the antigenic properties of Br and Ro nor between γ-A and γ-B (*9*). One of the horse antisera (Blue Boy) had antibodies for a γ-globulin which appeared to

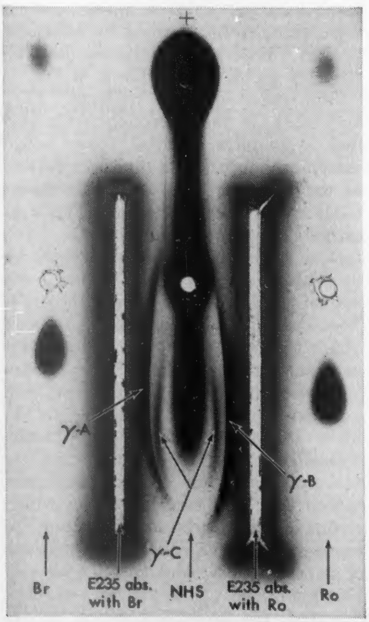

Fig. 2. The precipitin bands which appear when monkey antiserum E235, absorbed with myeloma sera Br and Ro, reacts with the electrophoretically separated γ-globulins of normal human sera. Because of endosmosis in agar gel, the electrophoretic patterns are displaced toward the cathode. At *p*H 8.6, all the proteins in serum are negatively charged and move toward the anode under the influence of an electric field.

correspond to γ-C. The γ-globulin found by Goodman with chicken antisera also appears to correspond to γ-C (*10*). It will be of interest to compare γ-A, γ-B, and γ-C to the γ-globulins, G_1 and G_2, found by Oudin with rabbit antibodies (*11*).

The availability of precipitating antibodies specific for three normal human γ-globulins should facilitate many studies of considerable interest concerning these γ-globulins, such as: quantitative estimation in serum and other body fluids (*11, 12*); fractionation and purification (*2, 13*); chemical structure, most particularly in the analysis of fragments resulting from enzyme digestion (*14*); antibody properties, in infectious diseases and diseases of supposed immunologic etiology (*15*); cytological localization by fluorescent antibody (*16*); and possible genetic differences (*17*). Of immediate clinical interest, the quantitative estimation of these γ-globulins in serum should be useful for early diagnosis and study of diseases which involve qualitative and quantitative changes in the γ-globulins, such as in multiple myeloma (*8*).

The finding of three "slow" γ-globulins with monkey antibodies, instead of the one usually found with horse or rabbit antibodies, focuses renewed attention on the classical principle of "immunologic perspective" for immunochemical investigations (*1*). As stated by Boyd, "it would be desirable, whenever possible, to use as the antibody-producing animal a species not too distantly related to the group whose relationships we wish to study, instead of using rabbits for all such experiments" (*1*).

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25 July 1960

Three-Dimensional X-ray Reflections from Anthracite and Meta-Anthracite

Abstract. Careful analysis of x-ray scattering intensities of demineralized meta-anthracites and high-rank anthracites formed during the Pennsylvanian geological period has revealed the presence of three-dimensional (hkl) reflections of graphite, demonstrating unequivocally that coals graphitize with metamorphism. Graphitization has been observed also with a coal formed before the Cambrian period, much earlier than most coals. A significant degree of graphitization occurs by coalification when the graphite-like layers attain a size of 25 to 30 angstroms as compared to 100 A or more by the heat treatment of amorphous carbons.

X-ray diagrams of most amorphous carbons and coals contain three or more diffuse bands in the angular positions of the (00l) and the two-dimensional (hk) reflections of graphite. With the development of the theory of diffraction in random layer lattices by Warren (*1*) it became possible to analyze the x-ray patterns of amorphous carbons and coals in terms of randomly stacked graphite-like layers (aromatic molecules) (*2*). Such analyses readily yield the size of the layers and the height of the stacks.

When carbons are heated at high temperatures, the dimensions of the parallel layer groups increase; the layer size increases more rapidly and attains a larger ultimate value than the height of the stack (*3*). With more extensive heat treatment, some layers assume positions that are oriented with neighboring layers. This three-dimensional orientation, manifested by modulations of the (hk) reflections, is identical with that of graphite and hence is termed graphitization (*4*). Franklin

and Warren observed the onset of graphitization whenever the layer size approached a value of about 80 to 100 A.

High-rank anthracites and meta-anthracites constitute the highest ranks in the classification series of coals (*5*). If coals ultimately become graphite (this view is often expressed) the highest rank coals should exhibit three-dimensional reflections of graphite. In Fig. 1 are shown the diffraction patterns of Ceylon graphite and a meta-anthracite from Newport County, Rhode Island. This coal was formed during the Pennsylvanian geological period. A demineralized sample containing 0.5 percent ash had the following composition by weight percent on a moisture- and ash-free basis: 97.9 C, 0.21 H, 1.7 O, and 0.2 N. The x-ray data were obtained on an XRD-5 diffractometer, with CuKα radiation. The recorded intensities were corrected for polarization.

As seen in Fig. 1, the meta-anthracite gave rise to all the observed three-dimensional reflections of graphite, that is, (101), (102), (103), (112), (201), (114), (203), (116). The (120) and (121) bands remained unresolved. The average layer diameter calculated from the line broadening of the (110) reflections was about 3000 A, and the average height of the stack calculated from the line broadening of the (002) reflections was 250 A. X-ray reflections of this and other meta-anthracites studied (*6*) unequivocally demonstrate

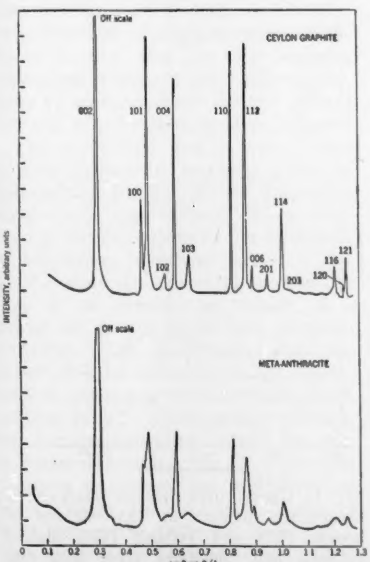

Fig. 1. X-ray scattering intensities of Ceylon graphite and meta-anthracite from Newport County, Rhode Island.

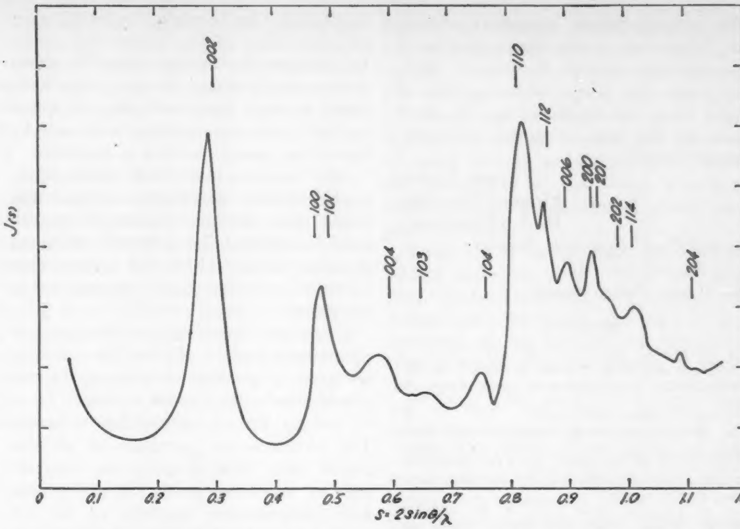

Fig. 2. X-ray scattering intensities of pre-Cambrian anthracite from Iron County, Michigan, showing modulation of the (11) band.

the presence of well-developed three-dimensional crystallinity of graphite.

A point of interest was to find whether coals of a different origin also developed graphitic structure. A coal from Iron County, Michigan, that is believed to have been formed before the Cambrian geological period, much earlier than most coals, was studied. Demineralized samples of this coal, containing 0.1 percent ash and 0.7 percent moisture, had the following composition by weight percent on a moisture- and ash-free basis: 93.4 C, 0.84 H, 1.2 N, 4.3 O, and 0.3 S. The coal can be classified as an anthracite (*5*). The recorded x-ray intensities were corrected for air scattering, polarization, and absorption, and were converted into atomic units by a trial-and-error procedure by matching the unmodulated portion (low-angle side) of the (11) band with the Warren equations. The results are shown in Fig. 2.

As shown in Fig. 2, the pre-Cambrian coal gave rise to many three-dimensional (hkl) reflections, indicating a significant degree of graphitization. Especially to be noted is the very pronounced modulation of the (11) band. The positions of the graphite reflections are marked in the figure for purposes of comparison. The (103), (104), (112), and (114) peaks are distinct; the (200) and (201) peaks are unresolved; the (202) peak appears as a shoulder; and the (204) peak is displaced somewhat. It is evident that the modulation of the (11) band preceded that of the (10) band; the modulation of the (11) band has resulted in resolution of the (110) and (112) peaks, whereas the (10) band remains unresolved. In the diffraction patterns of the meta-anthracites, most of the peaks are distinctly resolved (see Fig. 1).

Of particular interest is the size of the layers in the anthracite samples showing the beginning of the modulations of the (11) reflections. The layer diameter L_a was calculated by using $L_a = (a_2 - a_1)/\pi(s_2 - s_1)$, where s is defined from $s = 2 \sin \theta/\lambda$, θ being the Bragg angle and λ the wavelength of x-radiation; a_2 and a_1 are functions determined from the theoretical profile of a two-dimensional lattice reflection derived by Warren; subscripts 2 and 1 refer to the angular positions of the intensity curve where the intensity is one-half of the peak intensity. Values of L_a of the pre-Cambrian coal calculated from the (11) and (10) bands were 31.2 and 38.4 A, respectively. It is probable that closer agreement could have been obtained had the curve been demodulated. An estimate of 39.5 A for the layer size was obtained from the hydrogen-to-carbon ratio of the coal by assuming a pericondensed ring system.

A high-rank anthracite from Providence County, Rhode Island, having an ultimate composition, by weight percent, of 95.2 C, 0.89 H, 1.8 O, 0.3 N, and 1.8 S, had an x-ray pattern (not shown) very similar to that of the pre-Cambrian coal—that is, it showed the modulation of the (11) band. L_a as determined from the (11) band was only 26 A.

X-ray diagrams of these coals showed unequivocally that coals graphitize

with metamorphism regardless of origin. Moreover, a significant degree of graphitization occurs by natural process when the layers attain a size of about 26 A, as compared to 100 A or more by the heat treatment of amorphous carbons.

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5 August 1960

Effects of Supernumerary Chromosomes on Production of Pigment in Haplopappus gracilis

Abstract. One of the two types of supernumerary chromosomes found in *Haplopappus gracilis* effects pigment production in the achene walls. When one, two, and four supernumerary chromosomes were added to the basic complement, a corresponding increase in the amount of one type of pigment was found to occur. No overlapping of the effects on pigment production was observed among different numbers of supernumeraries or between the supernumeraries and normal chromosome complement.

Supernumerary chromosomes have been reported for many plant and animal species (*1*). They have been found to be devoid of genes in the usual sense, but in certain species a reduction in vigor, fertility, and sexual maturity can be attributed to their presence (*2*). Some of these effects are correlated with increased numbers of supernumeraries (*3*). However, attempts to relate a definite phenotypic effect with a certain supernumerary chromosome have been unsuccessful thus far. A possible exception may obtain in *Plantago*, in which one extra chromosome has been found to be associated with male sterility (*4*).

In a previous report of the supernumerary chromosomes in *Haplopappus gracilis* (Nutt.) Gray (*5*), it was pointed out that plants containing the larger type of supernumeraries could be distinguished by certain morphological characteristics of the leaves and stems. In addition, the achene coats of plants with supernumerary chromosomes were found to be a dark red color while the normal chromosome type was usually brown or, rarely, reddish at maturity.

The purpose of this preliminary study was to determine whether the larger type of supernumerary chromosomes exhibited an additive effect on pigment production in the achene coat as they were increased in number in the plant.

Using seed from reciprocal crosses of plants with $2n = 4 + 2$ and $2n = 4 + 3$, we grew a number of progeny in the greenhouse with normal diploids ($2n = 4$) having brown or reddish achenes. The chromosome numbers of all the plants were determined from somatic cells of immature heads. Several plants with chromosome numbers of $2n = 4 + 1$ and $2n = 4 + 2$ were obtained, but only two plants with $2n = 4 + 3$ and one with $2n = 4 + 4$ were grown to maturity. The mature achenes were harvested, dated, and stored at room temperature until used.

The pigments were extracted from ten weighed achenes in 3 ml of cold HCl in 90 percent ethyl alcohol, in a Tenbroeck all-glass tissue grinder, and the nonsoluble cell debris was removed by centrifugation. The solution containing the pigment from the brown achenes was yellow, while that from the reddish achenes and the red supernumerary fruits was varying shades of pink. Spectrophotometric analyses were carried out in a Beckman model DU spectrophotometer. Weight differences of the achenes were corrected after analysis.

The yellow pigment solutions, after dilution, yielded absorbance maxima at two points, 335–340 mμ and 270–275 mμ. The latter peak sometimes appeared only as a small shoulder in the absorbancy curve. The pink pigment solutions (undiluted) gave absorbance maxima at three points, one at 535–540 mμ, and the other two at or near the same wavelengths as the yellow after equivalent dilution. It thus appears that two and possibly three different pigments are present and that the yellow pigment occurs in the reddish diploid type as well as in plants having the supernumerary chromosomes.

In Fig. 1, the absorbance maxima of the two higher wavelengths of one sample have been plotted for each of the normal and aneuploid types. As the figure indicates, there is little or none of the pink pigment present in the brown achenes with a normal chromosome number. However, the data show a greater amount of the pink pigment in the achenes with supernumeraries than is found in the reddish type with the normal chromosome complement. In addition, there is an increase in the amount of pigment when one, two, and four supernumeraries are added to the normal complement. The plants with three supernumeraries produced less pigment than those with one and two, but it is important to note that this amount was somewhat greater than it is for the reddish diploid type and that it did not overlap with any of the other supernumeraries.

The yellow pigment occurred in greatest quantities in the brown achenes. A lesser amount was found in the reddish type, and the quantity varied in the achenes of plants with different numbers of supernumerary chromosomes. Whether there is a relationship between the general decrease in the amount of yellow pigment and the increase in red pigment in plants with up to two supernumeraries remains to be determined. A direct relationship might be expected if the two pigments were dependent upon a common precursor. An explanation is wanting also for the peculiar effect of three supernumeraries on the production of the red pigment. Nevertheless, the importance of the data presented here lies in the fact that each supernumerary chromosome exerts a definite effect upon the production of both yellow and pink pigments, and that no overlapping of the effects was found.

Genetic analysis, now in progress, should yield information on the mode of inheritance of pigment production.

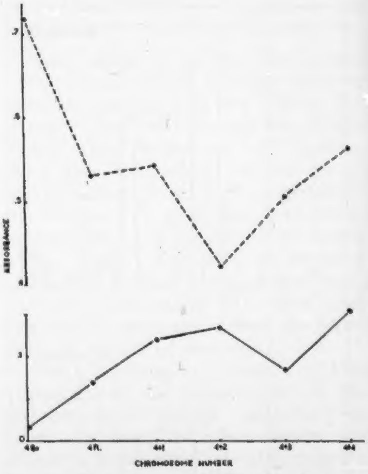

Fig. 1. Upper curve (dashed lines) shows absorbance maxima at 335–340 mμ of brown (4B) and reddish (4R) diploid achenes, and aneuploid types with one to four supernumerary chromosomes. The lower curve shows the absorbance maxima at 535–540 mμ for the same chromosome types.

Although the data presented here are admittedly meager, it would seem that the supernumerary chromosomes carry genes for pigment production which are similar to or the same as those on the normal chromosomes (*6*).

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20 July 1960

Estimate of the Human Load of Mutations from Heterogeneous Consanguineous Samples

Abstract. A formula is presented for the calculation of the mean number of lethal and abnormal equivalents per person. It has been applied to Brazilian, French, and Japanese data.

A number of the methods for the estimation of the mutational load in man are based on procedures in which only one class of consanguineous marriages is used (see *1*). For samples containing marriages with different degrees of consanguinity, a more general formula may be developed as follows:

The probability that a zygote from a consanguineous marriage will be homozygous for any one of the alleles present at a specific locus in the common ancestors is given by the coefficient of inbreeding. Suppose that each one of the common ancestors, considered here to be average individuals, is a carrier of a rare deleterious recessive mutation. The probability that the zygote will be homozygous for derivatives of any one of the deleterious genes is given by $f/2$. If we suppose now that the average individual carries not one, as postulated above, but D deleterious recessive mutations, the probability of homozygosity for any one of the D deleterious genes turns out to be $Df/2$. This value can be obtained by analyzing the frequency, x, of deleterious recessive homozygotes in the offspring of consanguineous marriages. Thus,

$$x = Df/2 \quad \text{and} \quad D = 2x/f \quad (1)$$

By a different reasoning Penrose (*2*) and Slatis *et al.* (*3*) came to the conclusion that in the special case of full first-cousin marriages ($f = 1/16$), $D = 32x$.

Now, given the fraction of abortions, miscarriages, stillbirths, mortality from birth to the mean marriage age, and anomalies, due to homozygosity for recessive genes, we could obtain the mean number, per person, of lethal equivalents acting in the different stages of development, as well as the mean number of abnormal equivalents. The summation of all these values would give us the total mean number of deleterious equivalents per person:

$$D = \sum_k \frac{2x}{f} \quad (2)$$

In samples containing not one but different types of consanguineous marriages, the frequency of homozygotes due to inbreeding is given by the mean coefficient of inbreeding:

$$\bar{f} = \sum_{j\neq 0} \frac{f_j n_j}{N} \quad (3)$$

where f_j is the jth coefficient of inbreeding, n_j is the number of pregnancies (for data on abortions and miscarriages) or children born (for stillbirths) or children born alive (for mortality from birth to the mean marriage age, and anomalies) associated with f_j, and N is $\sum_j n_j$. A rigorous analysis would score a monozygous twin pregnancy as one event and a dizygous twin pregnancy as two, but the use of any pregnancy—single or twin—as one event will introduce only a trivial error. Substituting for f in formula (2) the value $\bar{f}$, we obtain:

$$D = \sum_k \frac{2Nx}{\sum_{j\neq 0} f_j n_j} \quad (4)$$

In cases of mortality it is impossible to differentiate deaths caused by recessive genes from those caused by other factors. In such cases, as well as for anomalies in general, the frequency x of recessive homozygotes cannot be detected. It is possible, however, to obtain a rough estimate of x by subtracting the rates of mortality or anomalies in a suitable control sample (S_c) from those rates in the consanguineous (inbred) sample (S_i). Substituting (S_i-S_c) for x in formula (4), we get

$$D = \sum_k \frac{2N\,(S_i - S_c)}{\sum_{j\neq 0} f_j n_j} \quad (5)$$

that is, an estimate of the mean number of deleterious equivalents per individual. This formula does not correct for the error introduced into the data by those deaths where the individual was simultaneously homozygote for two or more lethals, or semilethals. Since the probability of this event is rather small, the error introduced would appear negligible.

When S_i is lower than S_c, D will take a negative value. This will not have genetic meaning with respect to deleterious equivalents and may be interpreted as an accident of sampling. If D is based on large samples, a negative value may be interpreted as indicating a very low mean number of deleterious equivalents per person.

Formula (5) has been applied to data on abortions plus miscarriages, stillbirths, and mortality from birth to the mean marriage age, from some Brazilian populations (*4*). The mean number of lethal equivalents per individual in the whole sample has been found to be 1.55. A large difference was found, however, between the two ethnic groups involved in the analysis; the mean number was −0.37 for Caucasians (almost all of Portuguese ancestry) and 9.12 for Negroes (*5*). The method of Morton, Crow, and Muller (*6*) has also been applied to these Caucasian and Negro data and lead to estimates close to those obtained according to formula (5): −0.24 for Caucasians and 10.46 for Negroes (*1*).

Formula (5) has been applied to Schull's (*7*) and Sutter and Tabah's (*8*) data and gave results similar to those obtained by the method of Morton *et al.* (*6*; *9*).

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References and Notes

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9. This work has been supported by grants from the Rockefeller Foundation, the National Research Council of Brazil, and the Research Council of the University of Paraná. We are indebted to Dr. William J. Schull, Dr. Newton E. Morton, Dr. James V. Neel and Dr. Warwick E. Kerr for reading and criticizing the manuscript.

15 August 1960

Association Affairs

Programs Planned for the AAAS New York Meeting

Section and society programs in geology and geography and the biological sciences to be presented at the New York meeting are given here. Programs in mathematics, physics, chemistry, and astronomy have been previously announced [*Science* **132**, 1259 (28 Oct. 1960)].

Geology and Geography

Section E. Symposium, cosponsored by the Ecological Society of America and the Geological Society of America: "Palynology," arranged by Calvin J. Heusser, American Geographical Society, with Harold L. Cousminer, New York University, presiding; 27 Dec. Papers will be presented on pleistocene palynology in the United States (Margaret B. Davis, Yale University and the University of Michigan); palynology and prehistory—the Southwest as an example (Paul S. Martin, University of Arizona); palynology as an adjunct to taxonomy (A. Orville Dahl, University of Minnesota); stratigraphic palynology as a tool for commercial geology (L. R. Wilson, Oklahoma Geological Survey); palynology, paleofloras, and paleoenvironments (Harold L. Cousminer).

Section E vice-presidential address and smoker: joint session of Section E, the Geological Society of America, and the Association of American Geographers, with William C. Krumbein, Northwestern University, presiding. The address, "Mineral Raw Materials in the National Economy," will be given by Howard A. Meyerhoff, Scientific Manpower Commission; 27 Dec.

AAAS Interdisciplinary symposium, joint program of Sections E–Geology and Geography, K–Social and Economic Sciences, O–Agriculture, P–Industrial Science, and the Association of American Geographers: "The Urban Frontier: A Conquest of Inner Space," arranged by Firman E. Bear, Rutgers State University, Frank C. Whitmore, Jr., U.S. Geological Survey, and Charles C. Morrison, Jr., American Geographical Society, with James E. Lash, Action, Inc., presiding; 28 Dec. Papers will be presented on application of census statistics to problems of urban renewal (Ross Eckler, Bureau of the Census); urban renewal and metropolitan affairs (Martin Millspaugh, Charles Center); two basic issues in local renewal policy (Coleman Woodbury, University of Wisconsin); renewal for industry—the opportunity and the problem (Dorothy A. Muncy, consulting city planner, Arlington, Va.); Newark, New Jersey—a case study in urban renewal (Paul Busse, Newark Economic Development Committee); urban renewal in New York City (George M. Raymond, Pratt Institute).

Symposium, joint session of Section E and the Geological Society of America: "Frontiers in the Earth Sciences, Part I," arranged by A. John Haworth, American Overseas Petroleum Limited, who will preside with William C. Krumbein, Northwestern University; 29 Dec. After an introduction on unity of purpose in the earth sciences by A. John Haworth, papers will be presented on a reappraisal of Appalachian geology (Herbert P. Woodward, Newark College of Rutgers University); the changing panorama of petroleum exploration (Robert E. King, American Overseas Petroleum Limited); current practice and trends in mineral exploration (Thomas S. Lovering, U.S. Geological Survey, Denver, Colo.); the status of paleontology (Ellis Yochelson, U.S. Geological Survey, Washington, D.C.); geochronometry by radioactive decay (Harold W. Krueger, Geochron Laboratories, Inc.); natural chromatography and the geochemistry of petroleum accumulation (Bartholomew S. Nagy, Fordham University). "Frontiers in the Earth Sciences, Part II" has also been arranged by A. John Haworth, with Hollis D. Hedberg, Princeton University, and Herbert P. Woodward, Rutgers University, presiding; 29 Dec. Papers will be presented on trends in geographic research (Preston E. James, Syracuse University); airborne exploration methods (F. Woods Hinrichs, Fairchild Aerial Surveys Inc.); satellite observations in relation to the earth sciences (Robert Jastrow, National Aeronautics and Space Administration); recent trends in marine geophysical exploration (Charles L. Drake, Lamont Geological Observatory); international cooperation at sea (Columbus O'D Iselin, Woods Hole Oceanographic Institution); convergence of evidence on climatic change and ice ages (Rhodes W. Fairbridge, Columbia University). The symposium will conclude with a panel discussion by all participants.

Symposium, joint session of Section E, the Geological Society of America, and the American Geophysical Union: "The Mohole," arranged by Harry S. Ladd, U.S. Geological Survey, Washington, D.C., who will preside with James R. Balsley, U.S. Geological Survey, Washington; 30 Dec. After introductory remarks by Harry S. Ladd, papers will be presented on project Mohole (Gordon G. Lill, Office of Naval Research); scientific objectives of the Mohole and a predicted section (Harry H. Hess, Princeton University); possibilities of wire-line logging methods in the Mohole (H. G. Doll, Schlumberger Well Surveying Corporation); drilling from floating vessels in the open sea (R. F. Bauer and A. J. Field, Global Marine Exploration Company); experimental drilling in deep water (Willard Bascom, National Research Council).

The Section E Committee will hold a luncheon meeting on 30 Dec.

Symposium, program of Section E and the Geological Society of America, cosponsored by Section D–Astronomy: "Selenology," arranged by Arnold C. Mason, U.S. Geological Survey, Washington, D.C., and L. W. L. Leroy, Colorado School of Mines, who will both preside; 30 Dec. Papers will be presented on the geologist's role in selenology (L. W. L. Leroy); making of a model moon (William R. Benton, Baltimore, Md.); the moon-mapping program at Army Map Service (Marian Hardy, Army Map Service); lunar terrain analysis (Jack R. Van Lopik, Waterways Experiment Station); physical divisions and photogeologic map of the moon (Arnold C. Mason and Robert J. Hackman, U.S. Geological Survey, Washington, D.C.); stratographic basis for a lunar time scale (Eugene M. Shoemaker, U.S. Geological Survey, Menlo Park, Calif., and Robert J. Hackman); a theory of the distribution of tektites (John A. O'Keefe and Barbara Shute, National Aeronautics and Space Administration); tektites and the cyrillid shower (John A. O'Keefe); nondestructive x-ray spectrographic analysis of extraterrestrial substances (Isadore Adler, U.S. Geological Survey); origin of the Ries Basin, Bavaria, Germany (Eugene M. Shoemaker, U.S. Geological Survey, Menlo Park, Calif., and E. C. T. Chao, U.S. Geological Survey, Washington, D.C.); Vredefort ring-structure—an astrobleme (meteorite impact structure) (Robert S. Dietz, Navy Electronics Laboratory); the application of geology to man's survival on the moon (Jack Green, North American Avia-

tion, Inc.); geological exploration of the moon (Paul J. Shlichta, California Institute of Technology).

The chairman for the entire program of Section E is A. John Haworth, American Overseas Petroleum Limited.

Association of American Geographers. Session for submitted papers, cosponsored by Section E: "Contributed Papers in Geography, I," arranged by Charles C. Morrison, Jr., American Geographical Society, with William O. Field, American Geographical Society, presiding; 27 Dec. "Contributed Papers in Geography, II" has also been arranged by Charles C. Morrison, who will preside; 30 Dec.

Panel discussion, cosponsored by Section E: "Programming the Use of Natural Resources," arranged by Leonard Zobler, Barnard College, who will preside; 30 Dec. Topics will be: the meaning and need for resource programming (Leonard Zobler); water resources programming (Garald Parker, U.S. Geological Survey); foreign trade policies affecting mineral fuels in the U.S. and Western Europe (Sam H. Schurr, Resources for the Future, Inc.); program planning for forests—needs and techniques (George F. Burks, U.S. Forest Service); resources of the sea (Louis S. Kornicker, Department of the Navy); conservation in the tri-state New York metropolitan region (William A. Niering, Connecticut College); conservation and resource programming (S. V. Ciriacy-Wantrup, University of California, Berkeley).

Symposium, cosponsored by Section E: "Late Pleistocene Events in Southern South America," arranged by Charles C. Morrison, Jr., American Geographical Society, with Junius B. Bird, American Museum of Natural History, presiding; 27 Dec. Papers will be presented on postglacial environmental changes in the Laguna San Rafael area, Southern Chile (Ernest H. Muller, Syracuse University); recent glacier variations in the Southern Andes (Donald B. Lawrence and Elizabeth G. Lawrence, University of Minnesota); glacier fluctuations on the eastern side of the South Patagonian Andes (John H. Mercer, Institute for Polar Studies, Ohio State University); sediments from the Argentine Continental Shelf—a preliminary report (M. Ewing, C. Fray, E. Dahlberg, Lamont Geological Observatory); the Chilean earthquake of 1960 (Pierre St. Amand, Institute of Inter-American Affairs).

Symposium (concurrent with the symposium on late Pleistocene events in South America) cosponsored by Section E: "Soviet Geography," arranged by Theodore Shabad, New York *Times* and *Soviet Geography*, with Charles B. Hitchcock, American Geographical Society, presiding; 27 Dec. Papers will be presented on the contributions of Soviet geography to the system of physical-geographical regions (W. A. Douglas Jackson, University of Washington); methodological controversy in Soviet geography (Robert Taaffe, Indiana University); heat and water balance research and the role of Soviet geography therein (Jacek I. Romanowski, University of Washington); climatological studies in the Soviet Union (Paul E. Lydolph, University of Wisconsin); the preparation of a Soviet geographer (Jack Villmow, Ohio State University); geography and economic planning as illustrated by the Soviet electric power industry (Aloys A. Michel, Yale University).

Panel discussion, cosponsored by Section E: "The New York Metropolitan Region of the Future," arranged by the Regional Plan Association, Inc., with William N. Cassella, Jr., Columbia University, presiding; 29 Dec. Topics will be: view of the future (C. McKim Norton, Regional Plan Association); the role of the federal government (Robert H. Connery, Duke University); cooperation through the Metropolitan Regional Council (Karl E. Metzger, Board of Chosen Freeholders, Middlesex County, New Brunswick, N.J.); the responsibility of the states (John E. Bebout, National Municipal League).

Symposium, cosponsored by Section E: "Economic Development and Investment in Africa South of the Sahara," arranged by Leonard Tow, African Research and Development Company, Inc., who will preside; 29 Dec. Papers will be presented on recent economic developments in West Africa (William A. Hance, Columbia University); some conditions essential to the acceleration of the rate of economic developments in West Africa (Edward Marcus, Brooklyn College); the influence of political philosophies on trade and investment in West Africa (Thomas P. Melady, Consultants for Overseas Relations); some factors influencing large-scale investment in Africa (F. Taylor Ostrander, American Metal Climax, Inc.); circumstances governing the rate and direction of flow of American private investment in Africa (E. Kennedy Langstaff, Transoceanic American Overseas Finance Company).

There will be a geographer's dinner on 29 Dec., sponsored by the New York-New Jersey Section of the Association of American Geographers.

There will be an Open House at the American Geographical Society arranged by Charles C. Morrison, Jr., 28 Dec., with George B. Cressey, Syracuse University, presiding.

National Geographic Society. There will be a lecture and color film, *Finding the World's Earliest Man*, by Matthew W. Stirling, Smithsonian Institution and Committee for Research and Exploration, National Geographic Society; 30 Dec.

National Speleological Society. The NSS is having two symposia, cosponsored by Section E. The first, "Physiological Adaptations of Cavernicolous Organisms," has been arranged by Brother G. Nicholas, F.S.C., University of Notre Dame, who will preside; 27 Dec. Papers will be presented on energy metabolism and activity of amblyopsids (Thomas L. Poulson, University of California, Los Angeles); some behavioral and physiological adaptations of cavernicolous bats (John W. Twente, University of Utah); a year-round study of a population of cave salamanders (Charles E. Mohr, Swiss Pines Park, Malvern, Pa.); observations on cavernicolous communities with special reference to mammoth cave (Orlando Park, Northwestern University, and Thomas C. Barr, Tennessee Polytechnic Institute); observations on cavernicolous behavior in Flint Ridge, Kentucky (Thomas L. Poulson); observations on the occurrence of fossil vertebrates in caves of Jamaica, British West Indies (Walter Auffenberg, AIBS Curriculum Study). The second symposium of the NSS, "Cave Mineralogy," is cosponsored by the Geological Society of America as well as by Section E. It has been arranged by William B. White, Pennsylvania State University, who will preside; 27 Dec. Papers will be presented on the aragonite-calcite problem (Rane L. Curl, Shell Development Company); the growth of stalactites (George W. Moore, U.S. Geological Survey); hexagonal stalactites from Rushmore Cave, South Dakota (William A. Bassett, Brookhaven National Laboratory, and Allen M. Bassett, Ohio Wesleyan University); secondary mineralization in Wind Cave, South Dakota (William B. White and George H. Deike III, Pennsylvania State University); monocrystalline speleothems (James F. Quinlan, Jr., University of Texas).

Biological Sciences

Section F–Zoological Sciences. Symposium, jointly with Section G–Botanical Sciences, co-sponsored by the American Society of Zoologists: "Life Under Extreme Conditions, Part I: Cells," arranged by A. Cecil Taylor, Rockefeller Institute, who will preside; 27 Dec. Papers will be presented on the effects of extreme cold on vertebrate cells (Harold Meryman, Naval Medical Research Institute); effects of extreme temperatures and desiccation on bacteria (Halvor Halvorson, University of Illinois); high-pressure studies on living cells (Douglas Marsland, New York University).

"Life under Extreme Conditions, Part II: Plants and Animals," arranged

by Charles P. Lyman, Harvard Medical School, who will preside; 27 Dec. Papers will be presented on structural adaptations of woody plants to arid environments (Jane Philpott, Duke University); adaptations of arctic and alpine plants to environmental conditions (Lawrence Bliss, University of Illinois); seasonal acclimatization in mammals and birds (J. S. Hart, National Research Council); adaptations of reptiles, birds, and mammals to high environmental temperatures (George A. Bartholomew, University of California, Los Angeles).

"Life Under Extreme Conditions, Part III: Human Studies" featured as an AAAS interdisciplinary symposium in the biological sciences, arranged by J. P. Marbarger, University of Illinois, who will preside; 28 Dec. After an introduction to and resumé of the problem (Hubertus Strughold, Brooks Air Force Base), papers will be presented on the effect of extreme pressure changes on the human being (Fred A. Hitchcock, Ohio State University); the responses of man to extreme conditions of hyperthermia (James D. Hardy, Naval Air Development Center); the effect on the human being of extreme conditions of hypothermia (Steven M. Horvath, Lankenau Hospital).

Symposium, held jointly with Section G–Botanical Sciences, cosponsored by the American Society of Zoologists: "Unsolved Problems in Biology, 1960: Submicroscopic Cellular Structure and Function," arranged by Barry Commoner and Viktor Hamburger, Washington University, with Barry Commoner presiding; 29 Dec. Papers will be presented on the biochemical significance of the endoplasmic reticulum (Philip Siekevitz, Rockefeller Institute); chemical and enzymatic organization of mitochondria (Albert L. Lehninger, Johns Hopkins University); genetic activity and chromosome structure (Jack Schultz, Institute for Cancer Research); molecular organization in the neuron (Peter F. Davison, Massachusetts Institute of Technology). Presentation of the papers will be followed by a discussion.

There will be a business meeting of Section F on 29 Dec.

Zoologists' dinner and vice-presidential address of Section F (a joint session of Section F, the American Society of Zoologists, and the Society of Systematic Zoology): "An Embryologist Visits Japan," by Viktor Hamburger, vice president for Section F; 29 Dec.; Emil Witschi, American Society of Zoologists, presiding.

Four-session symposium (joint program of the American Society of Zoologists, cosponsored by Section F and the Society of General Physiologists): "Spermatozoan Motility," arranged by David W. Bishop, department of embryology, Carnegie Institution of Washington, Baltimore; 29 and 30 Dec. Supported by a grant from the National Institutes of Health. Part I, with H. Burr Steinbach, University of Chicago, presiding; 29 Dec. Papers will be presented on sperm movement, problems, and observations (Lord Rothschild, University of Cambridge); a theory of the survival value of motility (F. D. Carlson, Johns Hopkins University).

Part II, with Keith R. Porter, Rockefeller Institute, presiding; 29 Dec. Papers will be presented on ultra-structure in relation to sperm motility (D. W. Fawcett, Harvard University); biophysical principles underlying sperm motility (F. G. E. Pautard, Leeds University, England); physicochemical aspects of sperm motility (L. Nelson, Emory University).

Part III, with R. J. Flipse, Pennsylvania State University, presiding; 30 Dec. Papers will be presented on metabolic reactions in spermatozoa (C. Terner, Boston University); respiration and oxidative phosphorylation in relation to sperm motility (P. H. Gonse, Centre de Recherches de Lyons, Lyons, France); ionic and osmotic requirements (G. W. Salisbury, University of Illinois).

Part IV, with Teru Hayashi presiding; 30 Dec. Papers will be presented on adenosine triphosphatase and acetylcholinesterase in relation to sperm motility (J. Tibbs, University of St. Andrews, Fife, Scotland); reactivation of extracted sperm-cell models in relation to the mechanism of motility (David W. Bishop); studies on isolated flagella (C. J. Brokaw, University of Minnesota).

Section F is a cosponsor of the program of the New York Academy of Sciences: "Current Problems in Electrobiology"; 30 Dec.

American Society of Zoologists. Two-session symposium, program of the Division of Comparative Physiology: "Physiology of Molluscs"; arranged by R. Boolootian, University of California, Los Angeles, Karl M. Wilbur, Duke University, presiding; 29 and 30 Dec. Part I. Papers will be presented on acclimation in molluscs (Earl Segal, Rice University); comparative physiology of digestion in molluscs (P. B. van Weel, University of Hawaii); nitrogen metabolism in the Mollusca (Kenneth Allen, University of California, Los Angeles); comparative functional morphology of the boring mechanism in boring gastropods (Melbourne R. Carriker, University of North Carolina).

Part II. Papers will be presented on neurohormones in molluscs (John H. Welsh, Harvard University); physiology of reproduction in molluscs (Paul S. Galtsoff, U.S. Fish and Wildlife Service, Woods Hole, Mass.); chemoreception in gastropods (Alan J. Kohn, Florida State University); variations in the heart rate of mussels from different habitats.

Symposium, program of the Division of Vertebrate Morphology: "Evolution and Dynamics of Vertebrate Feeding Mechanisms"; 28 Dec.; arranged by Perry W. Gilbert, Cornell University, and Bobb Schaeffer, American Museum of Natural History; Perry W. Gilbert, presiding. Papers will be presented on feeding mechanisms of Agnatha, Acanthodii, and Placodermi (Robert H. Denison, Chicago Natural History Museum); dynamics of the feeding mechanism in sharks (Stewart Springer, U.S. Fish and Wildlife Service); the origin of the holostean feeding mechanism (Bobb Schaeffer, American Museum of Natural History); the jaw of cyprinodontiform fishes, a pre-acanthopterygian experiment in protractility (Donn E. Rosen, Florida State Museum and University of Florida); feeding mechanisms: crossopterygians, amphibians, primitive reptiles (Everett C. Olson, University of Chicago); the feeding mechanism of snakes—its possible evolution (Carl Gans, University of Buffalo); feeding adaptations in Galápagos finches (Robert I. Bowman, San Francisco State College); the feeding mechanism in mammals (D. Dwight Davis, Chicago Natural History Museum); concluding comments by Alfred S. Romer, Harvard University.

Symposium, program of the Division of Endocrinology, cosponsored by AAAS Section F–Zoological Sciences, the Division of Developmental Biology, and the Genetics Society of America: "Evolution of Sex"; arranged by Emil Witschi, State University of Iowa, who will preside; 28 Dec. Papers will be presented on genetic exchange in bacteria and bacteriophages (Norton D. Zinder, Rockefeller Institute); genetics of mammalian sex chromosomes (Liane B. Russell, Oak Ridge National Laboratory); the sex chromatin—facts and interpretation (Susumu Ohno, City of Hope Medical Center, Duarte, Calif.); sex chromosomes and sex aberrations in man (Paul E. Polani, Guy's Hospital, London, England); epigenesis of sex determination (Joyce Bruner Lorand, Northwestern University); comments and perspectives (Emil Witschi).

There will be 19 sessions of contributed papers as follows:

Four sessions on "Animal Behavior and Sociobiology"; joint sessions of the Division of Animal Behavior and Sociobiology and the Section of Animal Behavior and Sociobiology of the Ecological Society of America; 28 and 29 Dec. Part I: "Early Experience"; Helen Blauvelt, N.Y. Upstate Medical Center, presiding. Part II: C. R. Carpenter, Pennsylvania State University, presiding. Part III: "Sexual Behavior"; Evelyn Shaw, American Museum of Natural

History, presiding. Part IV: "Sexual Behavior and Communication"; J. L. Fuller, Jackson Memorial Laboratory, presiding.

Three sessions on "Comparative Endocrinology"; 28 and 29 Dec. Part I: Berta Scharrer, Albert Einstein College of Medicine, presiding. Part II: Howard A. Bern, University of California, Berkeley, presiding. Part III: Jerry J. Kollros, State University of Iowa, presiding.

Four sessions on "Comparative Physiology"; 28 and 29 Dec. Part I: K. Schmidt-Nielsen, Duke University, presiding. Part II: "Comparative Physiology of Muscle"; arranged by C. Ladd Prosser, University of Illinois, who will preside. Part III: "Physiology of Arthropods"; J. H. Welsh, Harvard University, presiding. Part IV: "Physiology of Arthropods"; Talbot H. Waterman, Yale University, presiding.

Three sessions on "Developmental Biology"; 28, 29, and 30 Dec. Part I: Howard L. Hamilton, Iowa State University, presiding. Part II: Mac V. Edds, Jr., Brown University, presiding. Part III: Melvin Spiegel, Dartmouth College, presiding.

Two sessions on "Vertebrate Morphology"; 29 Dec. Part I: Richard J. Baldauf, Texas A. and M. College, presiding. Part II: Harvey I. Fisher, University of Southern Illinois, presiding.

There will also be three single sessions on 30 Dec. I: "Invertebrate Zoology, Parasitology, and Protozoology"; II: "Genetics and Cytology"; III: "Experimental Biology".

Two-session symposium, a joint program of the Division of Animal Behavior and Sociobiology and the Section of Animal Behavior and Sociobiology of the Ecological Society of America, cosponsored by Section F–Zoological Sciences and the National Association of Biology Teachers: "Teaching Animal Behavior"; arranged by E. B. Hale, Pennsylvania State University; 30 Dec.

Part I: "Animal Behavior in Biology Teaching"; E. B. Hale, presiding. Papers will be presented on animal behavior as a biological discipline (J. P. Scott, Jackson Memorial Laboratory); animal behavior in college biology (Benson E. Ginsburg, University of Chicago); animal behavior in secondary school biology (Arthur J. Baker, Crystal Lake High School, Crystal Lake, Ill.).

Part II: "Techniques in Teaching Animal Behavior"; Arthur J. Baker, presiding. Papers will be presented on film instruction (C. R. Carpenter, Pennsylvania State University); vertebrate materials (William C. Dilger, Cornell University); invertebrate materials (Thomas Smyth, Jr., Pennsylvania State University); special projects (Walter Gohman, Iowa State Teachers College Laboratory School, Cedar Falls, Iowa).

Panel discussion, a program of the Education Committee, cosponsored by AAAS Section F–Zoological Sciences: "Research Opportunities for Undergraduates"; arranged by William Etkin, Albert Einstein College of Medicine, who will preside; 28 Dec. Panelists: John L. Fuller, Jackson Memorial Laboratory; Lyle W. Phillips, National Science Foundation; Evelyn Shaw, American Museum of Natural History; David Stone, Worcester Foundation for Experimental Biology.

Demonstrations will be held in the morning and afternoon of 29 and 30 Dec.

Business meeting of the Division of Comparative Physiology; 28 Dec. Business meeting of the Division of Developmental Biology; 28 Dec. Supper and business meeting of the Division of Comparative Endocrinology; 28 Dec. Lunch and organization meeting of the Division of Vertebrate Morphology; 29 Dec.

A business meeting of the Society will be held 29 Dec.

Society of Systematic Zoology. Symposium, cosponsored by the American Society of Zoologists and AAAS Section F–Zoological Sciences: "Famous Zoologists: A series of anecdotal talks and recollections about some famous, recently-deceased zoologists"; arranged by Carl L. Hubbs, Scripps Institution of Oceanography, and George W. Wharton, University of Maryland; Carl L. Hubbs, presiding; 27 Dec. Papers will be presented on Thomas Barbour (Alfred S. Romer, Museum of Comparative Zoology, Harvard University); Leonhart Stejneger (Waldo L. Schmitt, U.S. National Museum); Stephen A. Forbes (Harlow B. Mills, Illinois Natural History Survey, Urbana); Joseph Grinnell (Alden H. Miller, Museum of Vertebrate Zoology, University of California, Berkeley); A. S. Pearse (George W. Wharton and Carl L. Hubbs).

Preview and panel discussion: "The New International Code of Zoological Nomenclature Adopted by the XVth International Congress of Zoology in London" (soon to be published); arranged by W. I. Follett, California Academy of Sciences, and Charles F. Lytle, Tulane University; W. I. Follett, presiding; 29 Dec. Panel members: Ernst Mayr, Museum of Comparative Zoology, Harvard University; Curtis W. Sabrosky, U.S. Department of Agriculture.

There will be one session for contributed papers, at which R. Tucker Abbott, Academy of Natural Sciences of Philadelphia, will preside; 27 Dec.

An informal visit to the American Museum of Natural History has been arranged by Horace W. Stunkard for 29 Dec.

The Society's annual breakfast and

business meeting will be held 28 Dec.

American Society of Naturalists. Two-session symposium, cosponsored by the American Society of Zoologists, the Ecological Society of America, and the Society for the Study of Evolution: "Modern Aspects of Population Biology"; arranged by Reed C. Rollins, Gray Herbarium, Harvard University; 27 Dec.

Part I; Reed C. Rollins, presiding. Papers will be presented on big and little populations—an amateur's excursion [L. C. Dunn, Columbia University (presidential address, American Society of Naturalists)]; niche specificity and diversity, with special reference to plankton (G. Evelyn Hutchinson, Yale University); the relation between laboratory and field investigations in population ecology (L. B. Slobodkin, University of Michigan).

Part II; Earl L. Green, Jackson Memorial Laboratory, presiding. Papers will be presented on experimental sympatric populations of *Clarkia* (Harlan Lewis, University of California, Los Angeles); phenotypic response to compatibility shift in wild populations of *Leavenworthia* (Reed C. Rollins); some recent theoretical contributions from zoogeography (E. O. Wilson, Harvard University); population effects of natural selection (Robert H. MacArthur, University of Pennsylvania).

A business meeting will be held 27 Dec.

Beta Beta Beta Biological Society. There will be an interim meeting of the Policy Committee on 27 Dec.

Beta Beta Beta is a cosponsor of the symposium of Alpha Epsilon Delta premedical honor society, "Career Opportunities in Medicine and Dentistry"; 29 Dec.

Biomedical Information Processing Organization. There will be one session of invited papers, arranged by Robert S. Ledley, National Biomedical Research Foundation, Inc., who will preside; 30 Dec. Papers will be presented on analog-digital devices and problems involved in suggesting standards (Harold K. Scramstead, National Bureau of Standards); function and nature of biomedical computer installation (Merrill M. Flood, University of Michigan); problems involved in sharing digital computer codes and programs (Walter M. Carlson, E. I. du Pont de Nemours and Company).

Organizational meeting and election of officers; Norman Z. Shapiro, presiding; 30 Dec.

Ecological Society of America. Symposium, cosponsored by AAAS Section H–Anthropology: "Ecology and Anthropology"; arranged by Paul Baker, Pennsylvania State University, who will preside; 28 Dec. Papers will be presented on ecology and nutritional stress

in man (Marshall Newman, U.S. Naval Museum); cultural ecology of Teotihuacan Valley (William Sanders, Pennsylvania State University); application of ecology to physical anthropology (Frank Livingston, University of Michigan); cultural ecology and ethnography (Charles Frake, Stanford University); the application of ecological theory to recent anthropology (Paul Baker).

Human ecology luncheon, arranged by George B. Happ, Principia College; 29 Dec.

There will be two sessions of contributed papers on "Plant Ecology"; 28 and 29 Dec. Part I; Murray F. Buell, Rutgers State University, presiding. Part II; R. H. Whittaker, presiding. There will also be two sessions of contributed papers on "Animal Ecology"; 28 and 29 Dec. Part I; R. S. Miller, University of Saskatchewan, presiding. Part II; C. H. Southwick, Hamilton College, presiding. There will be one session of contributed papers on "Aquatic Ecology"; 29 Dec.; Paul G. Pearson, Ford Foundation, presiding. There will also be a session of contributed papers on "Human Ecology"; 29 Dec.; George B. Happ presiding.

Three special tours have been arranged—to the New York Zoological Park, the American Museum of Natural History, and the New York Aquarium.

Nature Conservancy. Open meeting of the National Committee for Natural Areas for Schools; arranged by John W. Brainerd, Springfield College, who will preside; 27 Dec. An introductory paper, "Helping schools study natural areas: Outdoor research for indoor education," will be presented by Dr. Brainerd. This will be followed by a series of small-group deliberations led by Stanley A. Cain, University of Michigan; Leslie A. Clark, Society for the Protection of New Hampshire Forests; David E. Davis, Pennsylvania State University; Charles Mohr, Philadelphia Academy of Natural Sciences; and Jacob Shapiro, Wisconsin State College.

Society for the Study of Evolution. Business meeting and general session; Alfred E. Emerson, University of Chicago, presiding; 29 Dec. Presidential address: "Vestigia: Characters of Termites and the Processes of Regressive Evolution" (Alfred E. Emerson); invitational address: "Reproductive Substitution as a Method of Voluntary Human Evolution Preferable to Differential Birth or Death Rates" (Hermann J. Muller, Indiana University).

There will be four sessions of contributed papers. Session I: "Phylogenetic Aspects of Evolution"; 28 Dec. Session II: "Genetic Aspects of Evolution"; 28 Dec. Session III: "Speciation and Variation"; 29 Dec. Session IV: "Ecological Aspects and Methods"; 29 Dec.

Section G-Botanical Sciences. Symposium: "Machine Methods in Biology"; arranged by David Rogers, New York Botanical Garden; I. D. Welt, National Research Council, presiding; 30 Dec. Papers will be presented on computer simulation of taxonomic methods (David Rogers, New York Botanical Garden); computer applications—processing of nonnumerical data (T. P. Tanimoto, IBM Research Center, Yorktown Heights, N.Y.); the use of computers in systematic and other zoological research (Robert R. Sokal, University of Kansas); pattern recognition, morphology, and generation of hypotheses (Leonard Ornstein, Mount Sinai Hospital, New York).

Several other symposia are being held jointly with Section F–Zoological Sciences.

There will be two sessions for contributed papers at which Harriet B. Creighton, Wellesley College, will preside; 28 Dec. and 30 Dec.

Torrey Botanical Club. Two-session symposium, cosponsored by AAAS Section G–Botanical Sciences: "Fundamental Developments in Plant Growth"; arranged by Annette Hervey, New York Botanical Garden; 27 Dec.

Part I; Paul Burkholder, Brooklyn Botanic Garden, presiding. Papers will be presented on changing concepts of photosynthesis (Daniel Arnon, University of California); fundamental developments in the field of plant growth regulators (John Mitchell, Crops Research Division, U.S. Department of Agriculture, Beltsville, Md.); alteration of plant growth by chemicals (N. E. Tolbert, Michigan State University); "plant-animals" as experimental tools for growth studies (Seymour H. Hutner, Haskins Laboratories, New York).

Part II; George McNew, Boyce Thompson Institute, presiding. Papers will be presented on the photoperiodic control of flowering (Harry A. Borthwick, Crops Research Division, U.S. Department of Agriculture, Beltsville, Md.); test-tube studies on flowering (William S. Hillman, Yale University); relation of antimetabolites to plant growth (Thomas H. Jukes, American Cyanamid Company); recent progress and the goals of plant tissue culture (Walter Tulecke, Boyce Thompson Institute).

Botanists' luncheon and vice-presidential address of Section G, to be held jointly with AAAS Section G–Botanical Sciences and the Botanical Society of America; Father Charles A. Berger, presiding; 27 Dec. Speakers will be Father Berger; William C. Steere, New York Botanical Garden; and Barry Commoner, Washington University, who will give the vice-presidential address of Section G: "In Defense of Biology."

Meetings

Forthcoming Events

November

21–23. Fluid Dynamics, annual, Baltimore, Md. (R. J. Emrich, Div. of Fluid Dynamics, APS, Dept. of Physics, Lehigh Univ., Bethlehem, Pa.)

24–25. American Physical Soc., Chicago, Ill. (K. K. Darrow, APS, 538 W. 120 St., New York 27)

24–26. Central Assoc. of Science and Mathematics Teachers, 60th annual conv., Detroit, Mich. (L. A. Conrey, School of Education, Univ. of Michigan, Ann Arbor)

25–26. American Soc. of Animal Production, Chicago, Ill. (C. E. Terrill, Animal Husbandry Research Div., Agricultural Research Center, Beltsville, Md.)

25–26. National Council for Geographic Education, Cincinnati, Ohio. (L. Kenndmer, Univ. of Texas, Austin)

25–16. Bahamas Medical Conf., Nassau. (B. L. Frank, P.O. Box 4037, Fort Lauderdale, Fla.)

27–1. Latin American Cong. of Neurology, Santiago, Chile. (R. Nunez, Almirante Montt 485, Dep. 11, Santiago, Chile)

27–2. American Soc. of Mechanical Engineers, annual, New York, N.Y. (A. B. Conlin, Jr., ASME, 29 W. 39 St., New York 18)

27–5. International Federation of Agricultural Producers, 11th conf., New Delhi, India. (IFAP, 1624 Eye St., NW, Washington 6)

28–1. Entomological Soc. of America, Atlantic City, N.J. (R. H. Nelson, 4603 Calvert Rd., College Park, Md.)

29–2. American Medical Assoc., Washington, D.C. (F. Blasinggame, 1535 N. Dearborn St., Chicago 10, Ill.)

30–2. Steels in Reactor Pressure Circuits, symp., London, England. (Secretary, Iron and Steel Inst., 4 Grosvenor Gardens, London, S.W.1)

December

1–16. Commission for Climatology, 3rd session, London, England. (World Meteorological Organization, Campagne Rigot, 1, avenue de la Paix, Geneva, Switzerland)

2–5. Central American Medical Conf., 8th, Panama City. (A. Bissot, Departamento de Saud Publica, Ministerio de Trabajo, Prevision Social y Salud Publica, Panama)

3–6. Visual Communications, 4th annual intern. cong., Chicago, Ill. (Visual Communications Cong., 10600 Puritan Ave., Detroit 38, Mich.)

3–8. American Acad. of Dermatology and Syphilology, Chicago, Ill. (R. R. Kierland, First National Bank Building, Rochester, Minn.)

4–6. Spectroscopy, annual southern seminar, Gainesville, Va. (Annual Seminar on Spectroscopy, Univ. of Florida, Gainesville)

4–7. American Inst. of Chemical Engineers, annual, Washington, D.C. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36)

4–9. Radiological Soc. of North America, Cincinnati, Ohio. (D. S. Childs, 713 E. Genesee St., Syracuse 2, N.Y.)

5–7. American Soc. of Agricultural En-

gineers, winter, Memphis, Tenn. (J. L. Butt, ASAE, 420 Main St., St. Joseph, Mich.)

5–7. Electronic Industries Assoc., 3rd conf. on maintainability of electronic equipment, San Antonio, Tex. (E. B. Harwood, Office of the Secretary of Defense, Room 3D1018, Pentagon, Washington 25)

5–8. American Rocket Soc., 15th annual, Washington, D.C. (R. L. Hohl, ARS, 500 Fifth Ave., New York 36)

5–8. American Soc. of Agronomy, annual, Chicago, Ill. (L. G. Monthey, ASA, 2702 Monroe St., Madison 5, Wis.)

7–13. American Acad. of Optometry, San Francisco, Calif. (C. C. Koch, 1506–08 Foshay Tower, Minneapolis 2, Minn.)

9–10. The Myocardium—Its Biochemistry and Biophysics, New York, N.Y. (A. P. Fishman, New York Heart Assoc., 10 Columbus Circle, New York 19)

9–11. American Psychoanalytic Assoc., New York, N.Y. (D. Beres, 151 Central Park West, New York 23)

10–11. Academy of Psychoanalysis, New York, N.Y. (J. H. Merin, 125 E. 65 St., New York 21)

11–14. Hot Laboratory and Equipment Conf., 8th, San Francisco, Calif. (J. R. Lilienthal, Los Alamos Scientific Laboratory, P.O. Box 1663, Los Alamos, N.M.)

12–14. American Nuclear Soc. (Isotopes and Radiation Div.), San Francisco, Calif. (O. J. Du Temple, ANS, 86 E. Randolph St., Chicago 1, Ill.)

12–14. Water Pollution, natl. conf., Washington, D.C. (Natl. Conf. on Water Pollution, F. A. Butrico, Office of Engineering Resources, Div. of Engineering Services, U.S. Public Health Service, Washington 25)

12–16. Atomic Industrial Forum, conf., San Francisco, Calif. (D. J. Scherer, 3 E. 54 St., New York 22)

13–15. Eastern Joint Computer Conf., New York, N.Y. (E. C. Kubie, EJCC, Computer Usage Co., Inc., 18 E. 41 St., New York 17)

19–20. Statistical Mechanics, conf., London, England. (Organizing Secretary, Physical Soc., 1, Lowther Gardens, London)

22–2. Panamerican Diabetic Congress, 1st, British Honduras. (B. R. Hearst, Director, Diabetic Inst. of America, 55 E. Washington St., Suite 1646, Chicago 2, Ill.)

26–30. Inter-American Cong. of Psychology, 7th, Havana, Cuba. (G. M. Gilbert, Psychology Dept., Long Island Univ., Brooklyn 1, N.Y.)

26–31. American Assoc. for the Advancement of Science, annual, New York, N.Y. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5.

The following 52 meetings are being held in conjunction with the AAAS annual meeting.

AAAS Committee on Science and the Promotion of Human Welfare (B. Commoner, Shaw School of Botany, Washington Univ., St. Louis 5, Mo.). 26, 28, 29 Dec.

AAAS Cooperative Committee on the Teaching of Science and Mathematics (J. R. Mayor, Director of Education, AAAS, Washington, D.C.). 28, 29 Dec.

Academy Conference (J. G. Arnold, Jr., Loyola Univ., New Orleans, La.). 26–27 Dec.

Alpha Epsilon Delta (M. L. Moore, 7 Brookside Circle, Bronxville, N.Y.). 29 Dec.

American Assoc. of Clinical Chemists (H. Goldenberg, Dept. of Biochemistry, Hillside Hospital, P.O. Box 38, Glen Oaks, N.Y.). 26–27 Dec.

American Assoc. of Scientific Workers (Miss M. Yevick, 214 Western Way, Princeton, N.J.). 27 Dec.

American Astronautical Soc. (R. Fleisig, 58 Kilburn Rd., Garden City, N.Y.). 27 Dec.

American Astronomical Soc. (J. A. Hynek, Dearborn Observatory, Northwestern Univ., Evanston, Ill.). 28–31 Dec.

American Council on Women in Science (Miss E. B. Thurmann, Div. of Research Grants, National Insts. of Health, Bethesda 14, Md.). 27 Dec.

American Economic Assoc. (K. E. Boulding, Dept. of Economics, Univ. of Michigan, Ann Arbor). 26 Dec.

American Geophysical Union (R. Jastrow, NASA Theoretical Div., 8719 Colesville Rd., Silver Spring, Md.). 26 Dec.

American Nature Study Soc. (R. E. Hopson, 4138 S.W. Fourth Ave., Portland 1, Ore.). 27–30 Dec.

American Psychiatric Assoc. (P. H. Knapp, Boston Univ. School of Medicine, Boston, Mass.). 29, 30 Dec.

American Soc. of Criminology (D. E. J. MacNamara, New York Inst. of Criminology, 115–117 W. 42 St., New York 36). 26, 27 Dec.

American Soc. of Naturalists (R. C. Rollins, Gray Herbarium, Harvard Univ., 22 Divinity Ave., Cambridge 38, Mass.). 27 Dec.

American Soc. of Zoologists (R. L. Watterson, Dept. of Zoology, Northwestern Univ., Evanston, Ill.). 28–30 Dec.

American Sociological Assoc. (V. H. Whitney, Dept. of Sociology, Wharton School of Finance, Univ. of Pennsylvania, Philadelphia, Pa.). 28, 29 Dec.

American Statistical Assoc. (R. E. Lewis, New York Area Chapter, 55 Wall St., New York 15). 29 Dec.

Association of American Geographers (C. Morrison, Jr., American Geographical Soc., Broadway at 156 St., New York 32). 27–30 Dec.

Association for Computing Machinery (W. F. Cahill, NASA, 8719 Colesville Rd., Silver Spring, Md.). 29 Dec.

Astronomical League (Miss A. A. Pindar, Amateur Astronomers Assoc., Inc., 223 W. 79 St., New York 24). 28 Dec.

Beta Beta Beta Biological Soc. (Mrs. F. G. Brooks, P.O. Box 515, Ansonia Station, New York 23). 27 Dec.

Biomedical Information Processing Organization (R. S. Ledley, Natl. Biomedical Research Foundation, Silver Spring, Md.). 30 Dec.

Committee on Cosmetics, American Medical Assoc. (J. B. Jerome, 535 N. Dearborn St., Chicago 10, Ill.). 29 Dec.

Conference on Scientific Communication Problems (G. L. Seielstad, Technical Reports Group, Applied Physics Laboratory, Johns Hopkins Univ., Silver Spring, Md.). 26, 27 Dec.

Conference on Scientific Manpower (T. J. Mills, Natl. Science Foundation, 1951 Constitution Ave., NW, Washington 25). 27 Dec.

Conference on Scientific Manuscripts (N. Reingold, Dept. of History of Science and Medicine, Yale Univ., New Haven, Conn.). 29 Dec.

Ecological Soc. of America (R. S. Miller, Dept. of Biology, Univ. of Saskatchewan, Saskatoon, Saskatchewan, Canada). 26–31 Dec.

History of Science Soc. (D. J. de Solla Price, Dept. of History of Science and Medicine, Yale Univ., New Haven, Conn.). 27–29 Dec.

Institute of Management Sciences (M. M. Flood, Mental Health Research Inst., 205 N. Forest Ave., Ann Arbor, Mich.). 30 Dec.

Metric Assoc. (J. T. Johnson, 694 W. 11 St., Claremont, Calif.). 27 Dec.

Mountain Lake Biological Station (H. H. Hobbs, Jr., Univ. of Virginia, Charlottesville, Va.). 29 Dec.

National Acad. of Economics and Political Science (A. E. Taylor, Parkton, Md.). 27 Dec.

National Assoc. of Biology Teachers (P. Webster, Bryan City Schools, Bryan, Ohio). 27–30 Dec.

National Assoc. for Research in Science Teaching (G. Mallinson, School of Graduate Studies, Western Michigan Univ., Kalamazoo). 27 Dec.

National Assoc. of Science Writers (E. Ubell, Herald Tribune, New York, N.Y.). 27 Dec.

National Geographic Soc. (W. R. Gray, NGS, 16th and M Sts., NW, Washington 6). 30 Dec.

National Speleological Soc. (Brother Nicholas, FSC, Dept. of Biology, Univ. of Notre Dame, Notre Dame, Ind.). 27 Dec.

Nature Conservancy (J. W. Brainerd, Springfield College, Springfield, Mass.). 27 Dec.

New York Acad. of Sciences (D. Purpura, College of Physicians and Surgeons, Columbia Univ., New York, N.Y.). 30 Dec.

Science Clubs of America (Miss L. V. Watkins, Science Service, 1719 N Street, NW, Washington 6). 30 Dec.

Scientific Research Soc. of America (D. B. Prentice, 56 Hillhouse Ave., New Haven 11, Conn.). 29 Dec.

Sigma Delta Epsilon (Mrs. E. Cortelyou, Aeroprojects Inc., W. Chester, Pa.). 27–29 Dec.

Society for General Systems Research (C. A. McClelland, Dept. of History, San Francisco State College, 1600 Holloway Ave., San Francisco, Calif.). 29 Dec.

Society for the History of Technology (C. W. Condit, Dept. of English, Northwestern Univ., Evanston, Ill.). 27–29 Dec.

Society for Industrial and Applied Mathematics (J. Griesmer, IBM Research Center, Box 218, Yorktown Heights, N.Y.). 28 Dec.

Society for Industrial Microbiology (J. A. Ramp, 11 Van Dyke Rd., Waldwick, N.J.).

Society of the Sigma Xi (T. T. Holme, 56 Hillhouse Ave., New Haven 11, Conn.). 29 Dec.

Society for the Study of Evolution (H. H. Ross, State Natural History Survey, Urbana, Ill.). 27–29 Dec.

Society of Systematic Zoology (C. F. Lytle, Dept. of Zoology, Tulane Univ., New Orleans 18, La.). 27–29 Dec.

Tau Beta Pi Assoc. (R. H. Nagel, Tau Beta Pi Assoc., Univ. of Tennessee, Knoxville). 29 Dec.

Torrey Botanical Club (Miss A. Hervey, New York Botanical Garden, Bronx Park 56, N.Y.). 27 Dec.

27–14. Bahamas Surgical Conf., Nassau. (B. L. Frank, P.O. Box 4037, Fort Lauderdale, Fla.)

28. Association for Education in International Business, St. Louis, Mo. (J. N. Behrman, Univ. of Delaware, Newark, Delaware)

28–30. American Economic Assoc., St. Louis, Mo. (J. W. Bell, Northwestern Univ., Evanston, Ill.)

28–30. Econometric Soc., St. Louis, Mo. (R. Ruggles, Dept. of Economics, Yale Univ., New Haven, Conn.)

28–29. Linguistic Soc. of America, annual, Hartford, Conn. (A A. Hill, Box 7790, University Station, Austin 12, Tex.)

28–30. National Council of Teachers of Mathematics, Tempe, Arizona. (M. H. Ahrendt, 1201 16 St., NW, Washington 6)

29–31. American Physical Soc., Berkeley, Calif. (K. Darrow, APS, Columbia Univ., 116 St. and Broadway, New York, N.Y.)

(See issue of 21 October for comprehensive list)

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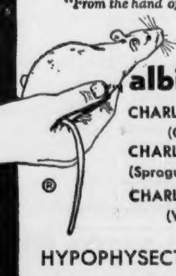

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